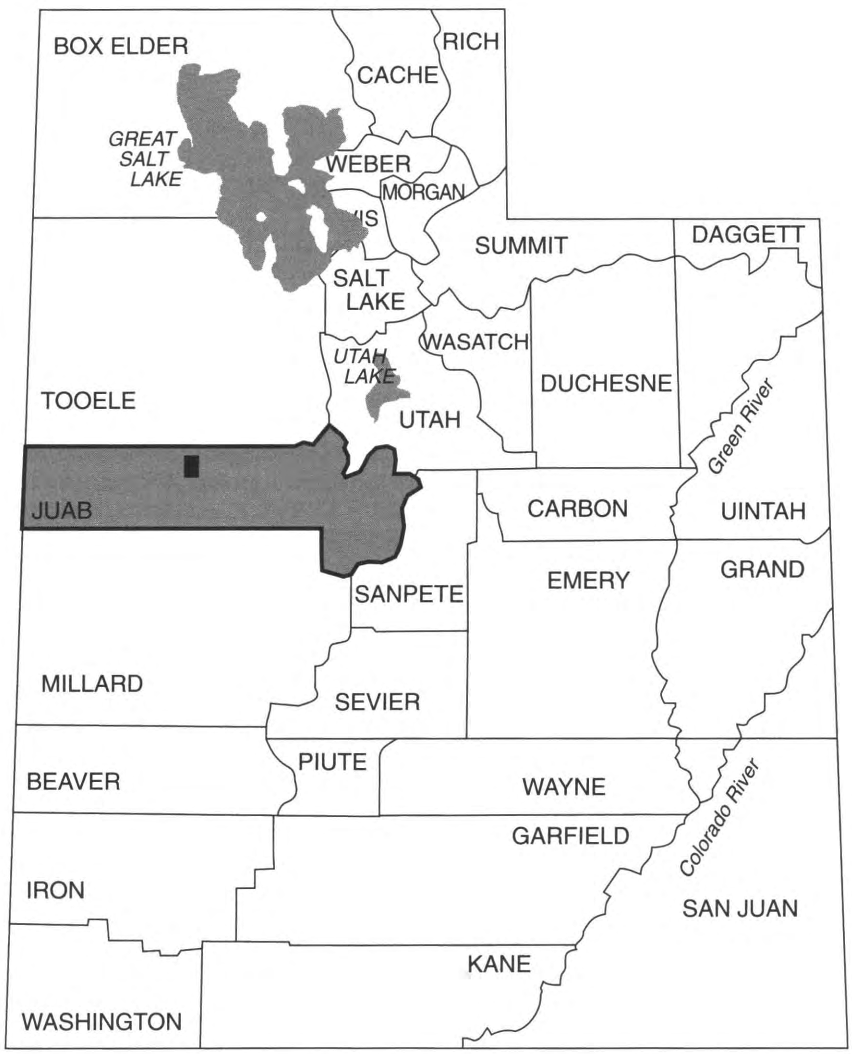
GEOLOGIC MAP OF THE KEG PASS QUADRANGLE, JUAB COUNTY, UTAH

by
Michael A. Shubat and Gary E. Christenson
Utah Geological Survey



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ABSTRACT

The Keg Pass 7.5′ quadrangle is in west-central Utah and includes the western part of Keg Mountain. The oldest rocks exposed in the quadrangle are Cambrian quartzite and limestone. These rocks were deformed during the Sevier orogeny, which produced at least two thrust faults in the quadrangle. Most of the quadrangle is underlain by Tertiary volcanic and intrusive rocks. Several calderas and cauldrons are in and near the Keg Pass quadrangle; they are part of a large, late Eocene to early Oligocene igneous center that spans the Thomas Range, Keg Mountain, and northern Drum Mountains. The major igneous events in the quadrangle were: (1) eruption of the Dead Ox Tuff and subsidence of the associated Flint Spring cauldron; (2) eruption of the Keg Tuff, subsidence of the associated Keg cauldron, and intrusion of granodiorite; (3) eruption of the Mt. Laird Tuff and collapse of the associated Thomas caldera; (4) eruption of the Joy Tuff, subsidence of the associated Dugway Valley cauldron, and intrusion of rhyolite porphyry; (5) eruption of the Dell Tuff from an unknown source; and (6) eruption of late Miocene Topaz Mountain Rhyolite from scattered local vents. Mineral occurrences in the quadrangle probably formed during this igneous activity and consist of volcanic-hosted gold prospects, polymetallic veins, and precious metals-enriched jasperoid bodies. Deposition of exposed sediments during Quaternary time was dominated by Lake Bonneville, which covered much of the northern and western parts of the quadrangle. Other surficial deposits include stream alluvium, colluvium, and alluvial-fan and eolian deposits. Potential industrial mineral and rock resources in the quadrangle include sand and gravel, cement rock, high-calcium limestone, zeolite minerals, crushed stone, and dimension stone.

INTRODUCTION

The Keg Pass quadrangle is in north-central Juab County, Utah, approximately 38 miles (61 km) northwest of Delta (figure 1) and 44 miles (71 km) west of Eureka. The quadrangle includes the western part of Keg Mountain, a low range in the Great Basin that is located between the Thomas Range to the west, the Simpson Mountains to the northeast, and Desert Mountain to the east. This report presents some of the results of a joint Utah Geological Survey - U.S. Geological Survey investigation of the geology and mineral potential of Keg Mountain as part of the Delta 1° x 2° quadrangle study of the Conterminous United States Mineral Assessment Program (CUSMAP). Bedrock geologic mapping was by Shubat mostly during 1986 through 1989, while Quaternary geologic mapping was by Shubat and Christenson in 1988 and 1989. This map and report contain refinements of information presented in Shubat (1987), and Shubat and Snee (1992).

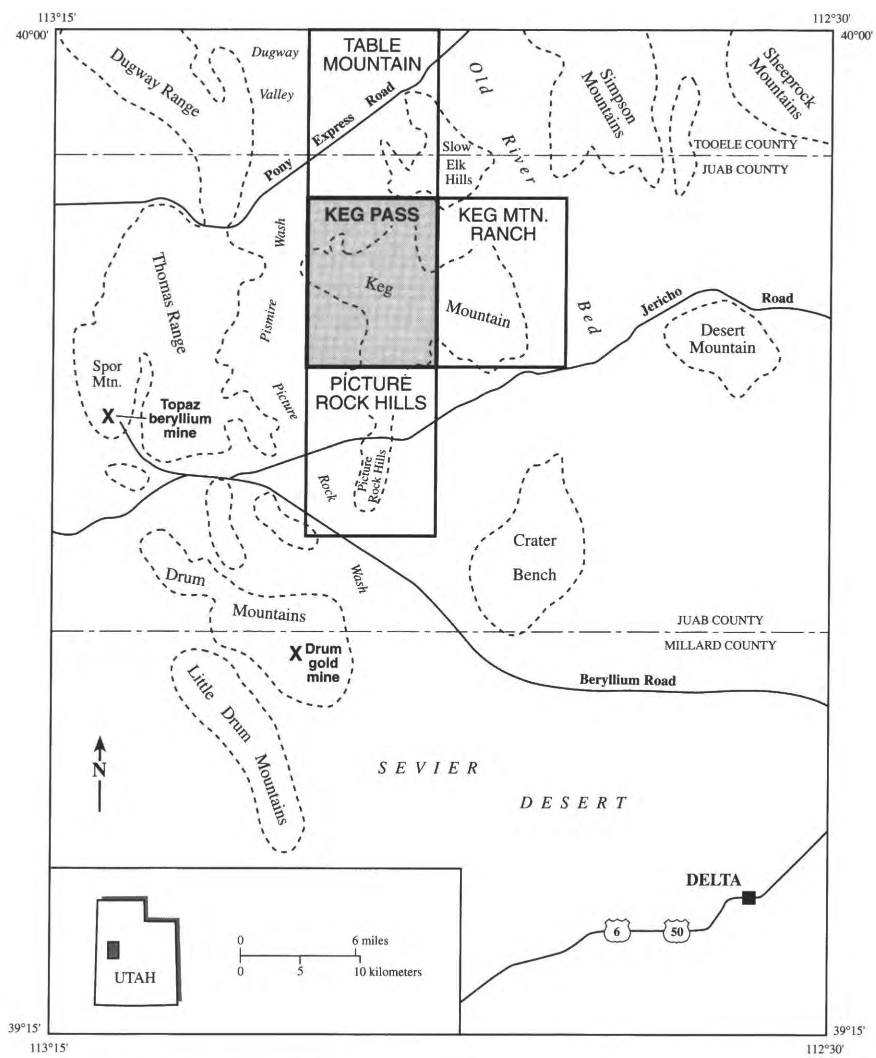

Figure 1. *Index map showing the location of the Keg Pass and adjacent quadrangles.*

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Previous geologic investigations of the bedrock geology at Keg Mountain began with Erickson's (1963) description of the volcanic rocks in western Juab County. Staatz and Carr (1964) described the Cambrian stratigraphy, Tertiary volcanic rocks, and mineral deposits of the nearby Thomas and Dugway Ranges. Shawe (1972) first recognized the presence of calderas in central Juab County. Based on his reconnaissance of the region in the 1960s, Shawe (1972) defined the Thomas, Keg, and Desert calderas and outlined three volcanic assemblages. Hintze and Robison (1975) redefined the Cambrian stratigraphy of west-central Utah. Lindsey and others (1975) determined the ages for many of the volcanic rocks in the region by the fission-track method. Lindsey (1975) studied the zeolitic alteration of tuffs at Keg Mountain. Staub (1975) produced the first detailed (1:24,000 scale) geologic map of the Picture Rock Hills 7.5´ quadrangle, which covers the southwestern portion of Keg Mountain. Morris (1978) reported hydrothermally altered rocks at northern Keg Mountain, and conducted a reconnaissance study of the area that included mapping and geochemical sampling. Lindsey (1979) mapped the nearby Thomas Range and northern Drum Mountains, and later (Lindsey, 1982) presented a detailed account of the regional volcanic stratigraphy and uranium mineralization. Lindsey (1982) was able to document the history of eruptions and collapse of the Thomas caldera and the younger, nested Dugway Valley cauldron. Unpublished reconnaissance mapping of Keg Mountain by Morris, Shawe, and Lindsey exists at a scale of 1:48,000 (H.T. Morris, written communication, 1986). Morris (1987) incorporated much of this unpublished mapping in the geologic map of the Delta 1° x 2° quadrangle (1:250,000 scale). Plavidal (1987) studied the petrology of Miocene igneous rocks in eastern Keg Mountain (Keg Mtn. Ranch 7.5´ quadrangle). Shubat (1987) presented a preliminary report of the geology and mineralization of Keg Mountain. Pampeyan (1989) compiled a 1:100,000 scale map of the Lynndyl 30´ x 60´ quadrangle that includes Keg Mountain and the Picture Rock Hills. Shubat and Snee (1992) provided $^{40}Ar/^{39}Ar$ dates on rocks in Keg Mountain and the Picture Rock Hills, as well as preliminary data on the geology and mineralization. Shubat (1999), and Shubat and others (1999) mapped the adjacent Picture Rock Hills and Keg Mtn. Ranch quadrangles, respectively, at 1:24,000 scale.

The Quaternary history and deposits of Keg Mountain, the Picture Rock Hills, and the surrounding Sevier Desert basin were first studied by Gilbert (1890). Subsequent studies were conducted by Varnes and Van Horn (1961), Currey (1982), Currey and others (1983), Oviatt (1984, 1987, 1989), and Oviatt and others (1992, 1994).

GEOLOGIC SETTING

Pre-Tertiary

The pre-Tertiary rock record at Keg Mountain and the Picture Rock Hills is incomplete due to extensive cover by Tertiary igneous rocks and Quaternary deposits, and deformation during the Sevier orogeny. Exposed sedimentary rocks are Early Cambrian marine shelf quartzite and Middle Cambrian miogeoclinal carbonate strata (Hintze, 1993). During the Cretaceous and early Tertiary Sevier orogeny, these strata were deformed and Lower Cambrian Prospect Mountain Quartzite was thrust over Middle Cambrian carbonate rocks.

Tertiary

Keg Mountain lies near the axis of the broad, east-west-trending Deep Creek-Tintic belt, which is defined by Cenozoic volcanic rocks, igneous intrusions, and mineral deposits (Shawe and Stewart, 1976; Stewart and others, 1977). Late Eocene to late Miocene regional extension produced high-angle normal faults that control some of the vents and mineral occurrences at Keg Mountain and in surrounding ranges.

Volcanism and related mineralization in the Thomas Range and Drum, Keg, and Desert Mountains has been divided into three stages (Shawe, 1972; Lindsey and others, 1975; Lindsey, 1982). The oldest stage (late Eocene to early Oligocene) consisted of emplacement of calc-alkaline, intermediate-composition volcanic rocks and related intrusions. The Dead Ox and Keg Tuffs were probably erupted from cauldrons at Keg Mountain during this stage. In the Thomas Range, this oldest stage culminated with the eruption of the Mt. Laird Tuff and concurrent collapse of the Thomas caldera (Lindsey, 1982). Mineral occurrences related to this stage include copper, manganese, and disseminated gold deposits located in the Drum Mountains district (Nutt and others, 1991) and may include polymetallic vein, polymetallic replacement, and gold occurrences at Keg Mountain (Shubat, 1987; this report).

The middle stage (early Oligocene) consisted of eruptions of rhyolitic ash-flow tuff, caldera subsidence, and intrusion of felsic stocks and plugs. In the Thomas Range, Lindsey (1982) associated the subsidence of the Dugway Valley cauldron with the eruption of the Joy Tuff. The Dell Tuff was also erupted (from an unknown source) during this stage. Concealed copper-lead-zinc-silver mineralization in the Picture Rock Hills quadrangle, in part hosted by the Joy Tuff, may be related to this stage (Shubat, 1999).

The youngest stage of activity (Miocene to Pleistocene) consisted of bimodal rhyolite-basalt volcanism. The Topaz Mountain Rhyolite was erupted from numerous vents during this stage. Lithophile mineral deposits formed during this stage include the world-class beryllium orebodies at Spor Mountain (figure 1) (Lindsey, 1977), and a variety of uranium and fluorspar occurrences in the Thomas Range (Staatz and Carr, 1964; Lindsey, 1982).

Quaternary

Deposition of exposed sediments was dominated by Lake Bonneville, an extensive late Pleistocene lake in the Great Basin in which Keg Mountain was an island (Currey and others, 1984). The lake began to rise in the Great Salt Lake basin about 30,000 years ago. It transgressed from the north into the Keg Pass quadrangle beginning in the northwest corner, probably about 20,000 years ago, and transgressed from the Dugway Valley (Great Salt Lake basin) and Sevier Desert basin into the southwestern part of the quadrangle about 17,000 years ago, based on elevation-time relationships (Oviatt and others, 1992). The lake transgressed to a maximum elevation of 5,221 feet (1,592 m) in the quadrangle (present elevation, which includes isostatic rebound)(Currey, 1982), covering the northern and western parts of the quadrangle and forming the Bonneville shoreline. This level was controlled by a threshold in southern Idaho where the lake overflowed into the Snake River. The Bonneville shoreline was occupied from about 15,000 to 14,500 years ago. About 14,500 years ago, the threshold failed and the lake dropped to the Provo level (Oviatt and others, 1992), located at 4,838 feet (1,476 m) on the south end of the Dugway Valley (Currey, 1982), where it once again stabilized and remained until about 14,000 years ago. At that time, the lake began a climate-controlled regression (Oviatt and others, 1992) and was gone from the quadrangle shortly after 14,000 years ago, based on the present lowest elevation of 4,640 feet (1,415 m) in the northwest corner of the quadrangle, only 200 feet (60 m) below the Provo shoreline (after Oviatt and others, 1992).

Prior to Lake Bonneville, Quaternary deposits were chiefly alluvium, colluvium, and alluvial-fan deposits, though lacustrine deposits in the Sevier Desert basin may be present in subsurface (see Oviatt and others, 1994). During and following the retreat of Lake Bonneville, these sub-aerial processes continued and eolian reworking of the lake deposits occurred.

MAP UNITS

Cambrian

Cambrian units are exposed in the north half of the quadrangle in folds and fault slivers, and their identification and age is based on the work of Hintze and Robison (1975). Because they are cut by thrust faults and depositional contacts are seldom exposed, estimated thicknesses reported in the text and on plate 2 are based on better exposures to the north in the Slow Elk Hills and subsurface data.

Prospect Mountain Quartzite (€pm)

The Prospect Mountain Quartzite consists of pinkish-gray to tan, rusty-weathering, medium-grained, thick-bedded quartzite with small-scale cross-bedding. Where exposed in the northern part of the Keg Pass quadrangle, the unit is in the upper plate of a thrust fault such that neither the upper nor lower contacts of the unit are exposed, and the thickness is unknown. Just north of the quadrangle in the Slow Elk Hills (figure 1), the Prospect Mountain Quartzite conformably underlies the Pioche Formation. Prospect Mountain Quartzite is pervasively brecciated in most exposures in the quadrangle, presumably the result of thrust faulting. Hintze and Robison (1975), following the recommendations of earlier workers, assigned a Lower Cambrian age to the unit. Morris (unpublished data) estimated the thickness of an incomplete section in the Slow Elk Hills to be about 820 feet (250 m). About 1,200 feet (366 m) of Prospect Mountain Quartzite was encountered in a drill hole (NW 1/4, section 34, T. 11 S., R. 10 W.) in the Keg Pass quadrangle (Getty Minerals Company, unpublished data).

Pioche Formation

The Pioche Formation consists of two members, the informal lower member and the overlying Tatow Member (Hintze and Robison, 1975).

Lower member (€pl): The lower member consists of intercalated beds of medium-bedded, dark-green to black, ledge-forming quartzite; thin-bedded, dark-olive-green to black phyllitic quartzite; and dark-olive-green phyllite. The lower member occurs as thin slivers between thrust faults in the northeast part of the quadrangle. Quartzite dominates in the lower parts of exposed sections and phyllite in the upper parts. Phyllite beds locally contain trilobite tracks. Rusty weathering is common. Hintze and Robison (1975) assigned a Lower Cambrian age to the member. Hintze and Robison (1975) placed the lower contact of the unit at the first occurrence of siltstone in the section. The base of the unit is not exposed in the Keg Pass quadrangle, but an estimated 150 feet (45 m) of the lower member is exposed. Thicknesses of 140 feet (43 m), 122 feet (37 m), and 287 feet (88 m) were measured to the north in the Table Mountain quadrangle (figure 2), and are minimum thicknesses.

Tatow Member (€pt): The Tatow Member (Hintze and Robison, 1975), as mapped in this report, consists of mottled orange-brown, oncolitic dolomite and white to gray oncolitic limestone. Exposures of the unit occur along the northern edge of the quadrangle in the north half of section 13, T. 11 S., R. 10 W. (all locations in this report are Salt Lake Baseline and Meridian), where it is in the upper plate of a thrust fault. Excellent exposures of the unit occur north of the quadrangle in the Slow Elk Hills (figure 1). There, the unit consists of thick- to medium-bedded, cliff-forming, orange-brown dolomite, which locally changes along strike to white to gray limestone. Our Tatow Member is bound above and below by dark-olive-green phyllite beds of the basal Howell Limestone and lower member of the Pioche Formation, respectively. Hintze and Robison (1975) assigned a Middle Cambrian age to the Tatow. Though poorly defined, outcrop width, dip, and slope in the Keg Pass quadrangle indicate the Tatow is less than 120 feet (36 m) thick. Three measured sections in the Table Mountain quadrangle that contain complete sections of the Tatow Member that are 94 feet (29 m), 86 feet (26 m), and 58 feet (18 m) thick (figure 2).

Howell Limestone (€h)

The Howell Limestone consists of light- to medium-gray, medium- to thick-bedded biosparite. It overlies the Pioche Formation in a syncline on the upper plate of a thrust fault exposed on the north margin of the quadrangle (section 12-13 line, T. 11 S., R. 10 W.). We somewhat arbitrarily define the base of the formation in the Keg Pass and Table Mountain quadrangles as the first phyllite overlying orange-weathering dolomite of the Tatow Member of the Pioche Formation. The Howell-Tatow contact might alternatively be placed higher in the section at the base of one of the overlying massive gray limestones (see figure 2); this would place one or more of the phyllites in the Tatow rather than the Howell. North of the study area, in the Table Mountain quadrangle, our base of the Howell Formation is well exposed, and consists of intercalated olive-green-gray phyllite and carbonate rock (figure 2). It also contains

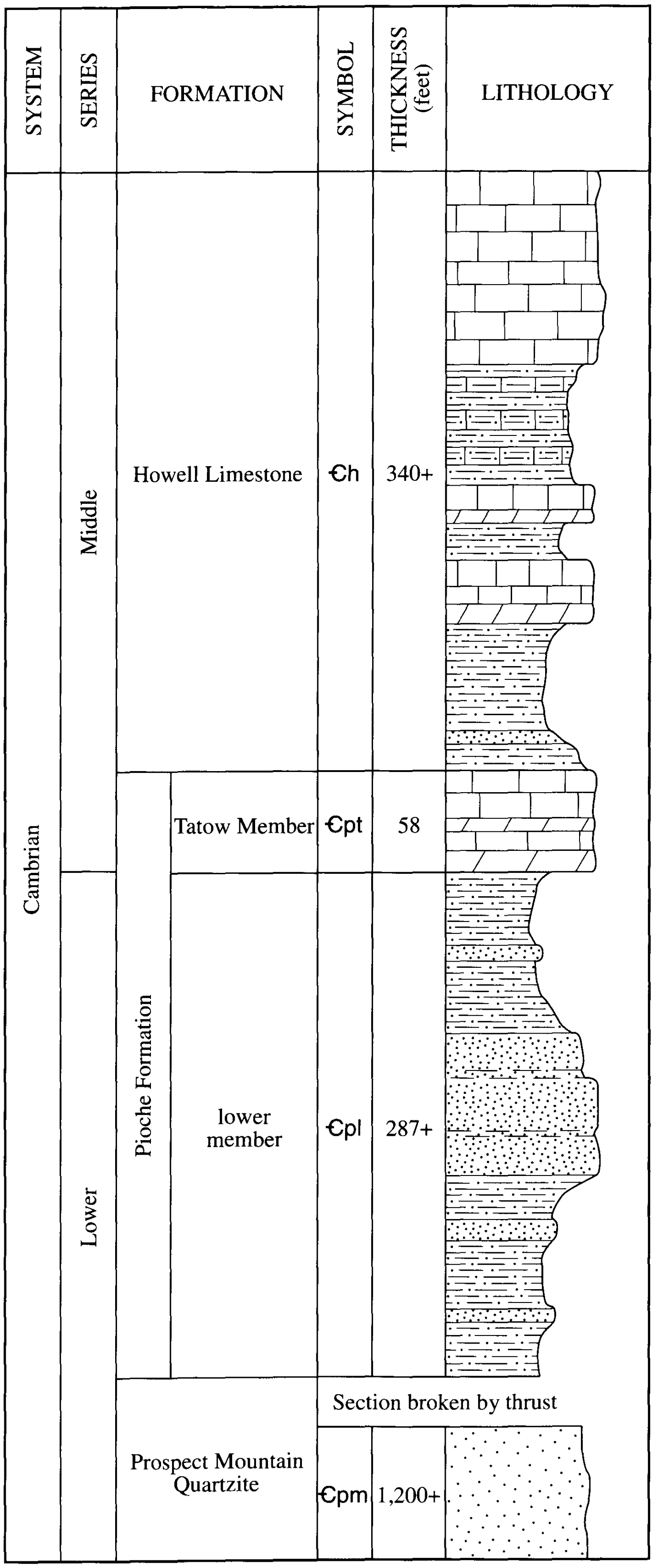


Figure 2. *Lithologic column for measured stratigraphic section of Cambrian rocks near Table Mountain (SW1/4 section 18, T. 10 S., R. 9 W.).*

minor interbeds of oncolitic, dolomitic limestone. The basal phyllite of the Howell is 56 feet (17 m) and 84 feet (26 m) thick in two measured sections in the Table Mountain quadrangle (figure 2). The Keg Pass quadrangle does not contain a complete section of the Howell Formation, but folded, discontinuous exposures indicate a thickness in excess of 400 feet (120 m).

Undifferentiated Cambrian Carbonate Rocks (€l)

Undifferentiated Cambrian carbonate rocks consist of light- to dark-gray, medium- to thick-bedded biosparite with minor shale and intraformational conglomerate interbeds. These rocks are exposed in the footwall of thrust faults in the northeastern part of the Keg Pass quadrangle and the adjacent Slow Elk Hills (figure 1). A tan boundstone (laminated dolomite) is present at the top of the exposed carbonate section in the southeast part of the Table Mountain quadrangle (northwest corner section 8, T. 11 S., R. 9 W.). Insufficient exposures of the unit exist to permit positive identification. This unit contains carbonate rocks that probably belong to the Middle Cambrian Howell Limestone, Chisholm Formation, Dome Limestone, Whirlwind Formation, or Swasey Limestone (after Morris, 1987). The maximum exposed thickness of a continuous section is 200 feet (60 m) in the N1/4, section 31, T. 11 S., R. 9 W. At this location, a drill hole intersected a minimum of 500 feet (150 m) of carbonate rock.

Tertiary and/or Cretaceous

Unnamed Conglomerate (TKc)

The unnamed conglomerate consists of well-rounded pebbles and cobbles of quartzite, chert, and limestone in a gray-green, sandy to silty matrix. The unit is very poorly exposed and occurs only in the north-central part of the Keg Pass quadrangle (SW1/4 section 25, T. 11 S., R. 10 W., NW1/4 section 36, T. 11 S., R. 10 W.). The distinguishing characteristic of the unit is the absence of volcanic rock fragments. The unnamed conglomerate unconformably overlies Paleozoic rocks. From the lack of volcanic clasts, we infer that the unnamed conglomerate is older than the Eocene volcanic rocks exposed on Keg Mountain. Hintze (1993) shows Cretaceous and/or Tertiary red conglomerates to the north (Cedar Mountain, Stansbury Mountains, Sheeprock Mountains - actually West Tintic Mountains, Ts of Pampeyan, 1989). Despite being a different color, and although its exact age is not know, we assume a Tertiary and/or Cretaceous age. The maximum exposed thickness of the unnamed conglomerate is 40 feet (12 m).

Tertiary

We have classified Tertiary rocks at Keg Mountain on the basis of modal analyses (appendix A) using quartz-alkali feldspar-plagioclase (QAP) trilinear plots of Streickesen (1976, 1978)(figure 4) and whole-rock, major-element chemical analyses (appendix B) using total-alkali-silica (TAS) plots of Le Bas and others (1986)(figure 5). Some samples and units shown on the figures are from or only exposed in the adjacent Keg Mtn. Ranch and Picture Rock

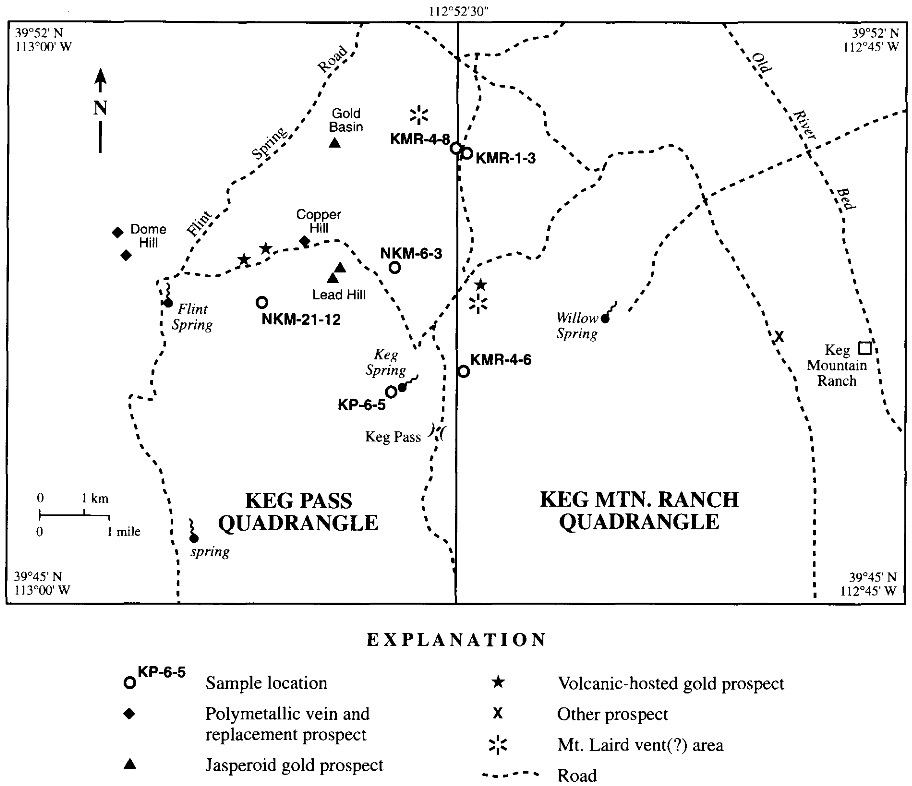


Figure 3. *Locations of samples dated by Shubat and Snee (1992)(see table 1), possible Mt. Laird Tuff vent areas, and prospects at Keg Mountain.*

Hills quadrangles. Analyses of samples from these adjacent quadrangles are also included in the appendices. Plate 1 shows the location of samples collected in the Keg Pass quadrangle for modal and major-element chemical analyses. Informal map-unit names are based on these classifications, lithology, and general outcrop locations. In this report, we propose two new formal names, Dead Ox and Keg Tuff for pyroclastic units that might be found outside Keg Mountain and the Picture Rock Hills. We also define vent areas for these and other units (see structure section). Dates on Tertiary rocks are summarized in table 1; the most precise and most accurate are the $^{40}Ar/^{39}Ar$ dates from Shubat and Snee (1992). Sample locations of Shubat and Snee (1992) are shown on figure 3 and plate 1.

Erickson (1963) originally described and informally named the oldest igneous rocks at Keg Mountain as "Keg Spring andesite and latite." Later, Shawe (1972) included these rocks in his "older assemblage of rocks" that he mapped as latitic, andesitic, and basaltic flows and agglomerates. Shawe (1972) divided his older assemblage into an older part, consisting of dark latite, rhyodacite, andesite, and andesitic basalt flows and agglomerates, that corresponds to Erickson's "Keg Spring andesite and latite," and a younger part consisting of flows and agglomerates of andesite and andesitic basalt. Staub (1975) informally referred to Shawe's (1972) "older assemblage" as the "Keg Spring andesite." Pampeyan (1989) followed Shawe's (1972) division and informally named the lower part the latitic, andesitic, and basaltic flows of Keg Mountain, and the upper part the latitic flows of Keg Mountain.

Our and adjacent (Shubat, 1999; Shubat and others, 1999) mapping shows that areas generally mapped as "Keg Spring andesite" by Staub (1975) and Erickson (1963), and the lower part of Shawe's (1972) and Pampeyan's (1989) division, consist of several of our map units: andesite of Keg Pass, the Keg Tuff (an ash-flow tuff that we define below), Mt. Laird Tuff (a sub-regional ash-flow tuff defined by Lindsey, 1979), and several intrusive units. Pampeyan's (1989) upper part of the "Keg Spring andesite" (his latitic flows of Keg Mountain) consist of the Mt. Laird Tuff.

Andesite of Keg Pass (Ta)

In this report, we adopt the informal name "andesite of Keg Pass" and restrict its usage to heterogeneous flows and intercalated lahars. Following the suggestion of a reviewer, we use Keg Pass, even though the andesite of Keg Pass is not exposed at Keg Pass, because of the wide distribution in the Keg Pass quadrangle, and to differentiate the unit from previously labeled andesitic units of Keg Spring and Keg Mountain. The unit is best exposed in the SW1/4, section 31, T. 11 S., R. 9 W.

The andesite of Keg Pass consists of a heterogeneous sequence of dark-colored dacitic, latitic and andesitic flows and lahars. Flow rocks dominate and contain phenocrysts of andesine, biotite, hornblende, quartz, clinopyroxene, and magnetite in a trachytic matrix. Some flows are coarsely porphyritic, containing plagioclase crystals as long as 0.59 inches (15 mm). Lahars commonly occur at the base of the unit and contain clasts of andesite of Keg Pass, quartzite, limestone, and, locally, Mt. Laird Tuff. Some of the basal lahars are deeply weathered, and contains rounded clasts of Paleozoic rocks and subangular Mt. Laird Tuff, suggesting fossilized colluvium.

Modal analysis of one sample (figure 4 and appendix A) shows that, based on phenocryst composition, the rock is an andesite. However, figure 5 shows that whole-rock analyses of three other samples of the unit (appendix B) plot within the dacite and latite compositional fields of Le Bas and others (1986). We continue to use the term andesite for the unit because it is so variable, is darker than most latites and dacites in the area, and phenocryst content can be mapped in the field.

Widespread propylitic alteration (in varying degrees of intensity) of the unit is seen in mineralogic changes; plagioclase is altered to montmorillonite + calcite (unpublished x-ray diffraction data), hornblende and clinopyroxene to chlorite + calcite + epidote, and biotite to chlorite. Magnetite rims commonly surround altered ferromagnesian minerals. Alteration of the matrix produced montmorillonite + chlorite + calcite + quartz + zeolite (unpublished x-ray diffraction data). Pyrite is present in the matrix of some propylitized rocks.

Lindsey (1982) reported an average fission-track age

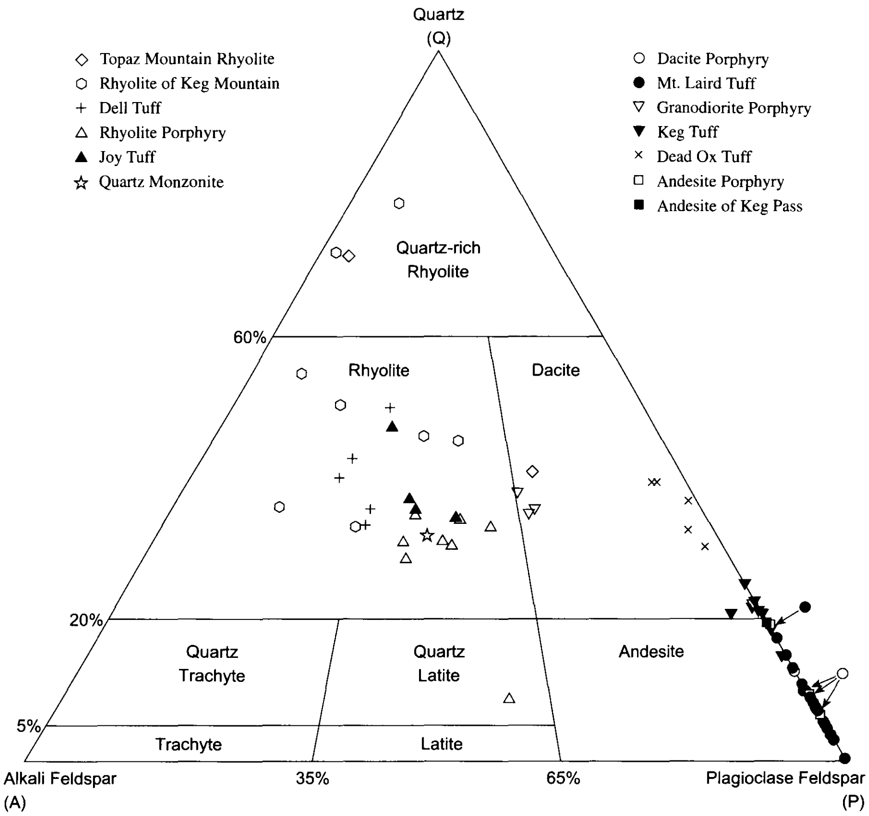


Figure 4. Modal analyses of igneous rocks from Keg Mountain and the Picture Rock Hills plotted on a trilinear QAP diagram. Q is the quartz content, A is the alkali feldspar content, and P is the plagioclase content as determined by point counting grains in holocrystalline rocks and phenocrysts in aphanitic rocks. Compositional fields from Streckeisen (1976, 1978). Compositional field for dacite is the same as the field for granodiorite, its plutonic equivalent. Appendix A lists the modal analyses. Not all rock types shown and listed are exposed in this quadrangle (see appendix).

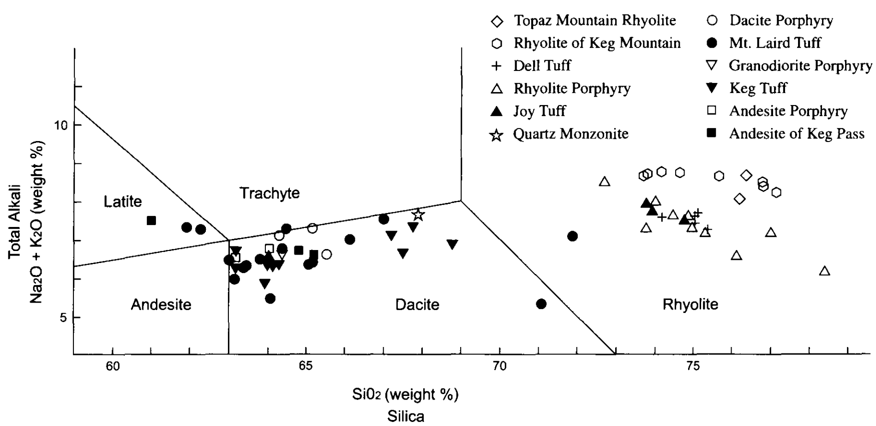


Figure 5. Total alkali (Na_2O+K_2O) versus silica (SiO_2) (TAS) diagram for igneous rocks at Keg Mountain and the Picture Rock Hills. Compositional fields for volcanic rocks from Le Bas and others (1986). Appendix B lists the major element whole-rock geochemical analyses. Not all rock types shown and listed are exposed in this quadrangle (see appendix).

(corrected from an earlier publication) of 39.4 ± 0.7 Ma for samples of what is apparently our andesite of Keg Pass, collected in the western part of the quadrangle. Our examinations and work by Shubat and others (1999) show that the age of this andesite unit spans the ages of the Dead Ox, Keg, and Mt. Laird Tuffs and several other units in the quadrangle. In the eastern part of the quadrangle (NW¼, section 6, T. 12 S., R. 9 W.), the Keg Tuff (Tk; 36.77 ± 0.12 Ma, table 1) clearly overlies the andesite of Keg Pass, indicating the minimum age of the unit at this location. To the east in the adjacent Keg Mtn. Ranch quadrangle, however, the Keg Tuff appears to underlie the andesite of Keg Pass and clasts of Mt. Laird Tuff (Tml; 36.54 ± 0.06 Ma, table 1) occur in the lahar facies of the andesite of Keg Pass. The latter indicates the maximum age of the unit at this location. The andesite of Keg Pass is at least in part older than the Dead Ox Tuff (defined below) because clasts of the andesite occur in the Dead Ox Tuff.

No complete section of the andesite of Keg Pass is exposed in the quadrangle. The maximum exposed thickness of the unit is 200 feet (60 m) in the NW¼, section 6, T. 12 S., R. 9 W.

Andesite Porphyry (Tap)

Andesite porphyry occurs as small sub-volcanic intrusions that previous workers (Erickson, 1963; Shawe, 1972; Morris, 1987; Pampeyan, 1989) grouped with the oldest igneous rocks of Keg Mountain (see above). We do not give these intrusions a more formal name because of their limited extent and the small likelihood that the unit will be correlated with rocks in adjacent ranges. Andesite porphyry occurs as three elongate plugs in the center of the quadrangles (N½ section 6, T. 12 S., R. 9 W.; NE¼ section 1, T. 12 S., R. 10 W.). The largest and two other exposures are less than 2,500 feet (760 m) and less than 1,500 feet (460 m) in largest dimensions, respectively. Andesite porphyry consists of dark-brown to black, brown-weathering andesite with abundant 0.01 to 0.2 inch (0.2 to 5 mm) phenocrysts of plagioclase, quartz, hornblende, biotite, and augite, and lesser amounts of zircon and magnetite in an aphanitic matrix. Flow features in the rock include bent biotite crystals and a weakly developed trachytic texture. Modal analyses of three samples (figure 4 and appendix A) show that based on phenocryst compositions these rocks are andesite. However, figure 5 shows that whole-rock analyses of two of these samples (appendix B) plot within the dacite compositional field of Le Bas and others (1986). We have chosen to call these rocks andesite because of their close association with the andesite of Keg Pass, and phenocrysts can be mapped, while chemistry can not.

Table 1. *Summary of dates for igneous rocks at Keg Mountain. Figure 3 shows the locations of samples dated by $^{40}Ar/^{39}Ar$ age-spectrum methods by Shubat and Snee (1992).*

Map Unit	Map Symbol	Sample Number	Mineral/Method	Date (Ma)	Average (Ma)	Reference
Andesite of Keg Pass (?)	Ta	?	?/fission track		39.4 ± 0.7	Lindsey, 1982
		K15-A	zircon/fission track	37.2 ± 1.6		Lindsey & others, 1975
		K15-A	apatite/fission track	39.7		Lindsey & others, 1975
		K50-A	zircon/fission track	38.3 ± 1.5		Lindsey & others, 1975
Keg Tuff	Tk	KP-6-5	biotite/Ar-Ar	36.77 ± 0.12		Shubat & Snee, 1992
Granodiorite porphyry	Tgd	U29B	zircon/fission track	36.6 ± 1.6		Lindsey, 1982
Mount Laird Tuff	Tml	KMR-4-8	biotite/Ar-Ar	36.56 ± 0.1		Shubat & Snee, 1992
		KMR-4-8	hornblende/Ar-Ar	36.59 ± 0.29	36.54 ± 0.06	Shubat & Snee, 1992
		NKM-21-12	biotite/Ar-Ar	36.48 ± 0.14		Shubat & Snee, 1992
		NKM-21-12	biotite/K-Ar	37.1 ± 1.5		this report
Dacite porphyry	Tdp	NKM-6-3	biotite/Ar-Ar	36.49 ± 0.15		Shubat & Snee, 1992
		NKM-6-3	biotite/K-Ar	36.2 ± 1.4		this report
Joy Tuff	Tj	KMR-1-3	sanidine/Ar-Ar	34.92 ± 0.14	34.88 ± 0.06	Shubat & Snee, 1992
		KMR-1-3	biotite/Ar-Ar	34.84 ± 0.14		Shubat & Snee, 1992
		U240	zircon/fission track	36.9 ± 1.7		Lindsey, 1982
Rhyolite porphyry	Trp	KMR-4-6	sanidine/Ar-Ar	35.04 ± 0.10	35.14 ± 0.15	Shubat & Snee, 1992
		KMR-4-6	biotite/Ar-Ar	35.25 ± 0.13		Shubat & Snee, 1992
		DRS-282-63	zircon/fission track	30.8 ± 1.8		Lindsey & others, 1975
Dell Tuff	Td	various	various/fission track		32.0 ± 0.6	Lindsey, 1982
		K20-A	sphene/fission track	33.6 ± 1.8		Lindsey, 1982
		K48-A	sphene/fission track	32.5 ± 1.6		Lindsey, 1982
		K40-A	zircon/fission track	33.8 ± 1.3		Lindsey, 1982
Rhyolite of Keg Mountain	Tkm	46V	sanidine/K-Ar	6.7 ± 0.3		Plavidal, 1987
		67AFT	sanidine/K-Ar	6.9 ± 0.3		Plavidal, 1987
		105V	sanidine/K-Ar	6.9 ± 0.3		Plavidal, 1987
		K-49-A	zircon/fission track	10.3 ± 0.6		Lindsey & others, 1975
		K-49-B	zircon/fission track	9.6 ± 0.9		Lindsey & others, 1975
Topaz Mountain Rhyolite	Ttm	K47-TR-A	sphene/fission track	7.8 ± 0.6		Lindsey & others, 1975
		K39-TR-A	zircon/fission track	8.2 ± 0.5		Lindsey & others, 1975

In the north half of section 6, T. 12 S., R. 9 W., the plugs intrude the andesite of Keg Pass (Ta) and are overlain by the Keg Tuff (Tk); this roughly dates the unit between 39.4 ± 0.7 Ma and 36.77 ± 0.12 Ma (table 1).

Dead Ox Tuff

We propose the formal geologic name, Dead Ox Tuff, for a lithostratigraphic unit of formational rank. We name the unit for exposures of lithic-crystal, ash-flow tuff located near Dead Ox Wash. This unit is not equivalent to the unit that Morris (1978) informally named latite of Dead Ox Wash. We designate the type locality as the cut in the northeast bank of a stream in the northeast part of the Keg Pass quadrangle (sample site NKM-1-9 and foliation in SE¼ SW¼ SW¼, section 29, T. 11 S., R. 9 W.). The Dead Ox Tuff consists of three informal lithostratigraphic members: (1) stratified tuff, 2) lithic-crystal, ash-flow tuff, and 3) megabreccia. Lithic-crystal, ash-flow tuff occurs as distinct beds, as at the type locality, as well as forming the matrix of megabreccia. We designate a stream cut (NW¼ SE¼ SW¼, section 26, T. 11 S., R. 10 W.), about 3 miles (5 km) west of the type section, as a reference section for the megabreccia member of the Dead Ox Tuff. This is one of the few locations where the matrix of the megabreccia is exposed. Exposures of the stratified tuff member occur in the SE¼ SE¼, section 30, T. 11 S., R. 9 W., just west of the type locality, and the tuff is not in contact with the other members. The Dead Ox Tuff is known only at Keg Mountain. Many previous workers mapped the megabreccia member as Paleozoic rocks (Erickson, 1963; Shawe, 1972; Morris, 1987; Pampeyan, 1989) and did not recognize the other members. Staub (1975) mentioned the presence of coarse breccia with a possible igneous matrix at Keg Mountain, which may be our megabreccia member.

Stratified tuff member (Tdow): The stratified tuff member consists of poorly exposed, tan to orange, thin-bedded to laminated (0.4 to <0.04 inches [1 cm to <1 mm]), volcanic sandstone and siltstone, and ash-rich (grain size <0.08 inch [<2 mm]) tuff that was at least partially water laid. Sand-sized, crystal fragments consist of quartz, plagioclase, and biotite; and lithic fragments consist of quartzite, limestone, and volcanic rock. The unit is restricted to an area in and near the southeast part of section 30, T. 11 S., R. 9 W. The unit is intruded by a dacite porphyry plug (Tdp) and as a result is pervasively altered; argillic alteration is common. One sample contained an alteration assemblage consisting of quartz, calcite, potassium feldspar, biotite, and pyrite. The unit overlies the andesite of Keg Pass. Its age is bracketed by the date on a dacite porphyry intrusion (Tdp) (36.49 ± 0.15 Ma, table 1), similar to the one that cuts the stratified tuff member, and the age of the andesite of Keg Pass (Ta)(39.4 ± 0.7 Ma, table 1). The unit appears to be less than 40 feet (12 m) thick.

Lithic-crystal, ash-flow tuff member (Tdo): The lithic-crystal, ash-flow tuff member of the Dead Ox Tuff consists of tan, orange, and pale-green, thick-bedded, moderately to poorly welded, dacitic ash-flow tuff. It contains abundant lithic fragments (~20 to 25%), from 0.04 to 16 inches (1 mm to 40 cm) in diameter, of quartzite, limestone, black phyllite, andesite, and pumice. The slightly flattened pumice clasts impart a crude layering to the rock. Phenocrysts consist of plagioclase, quartz, biotite, and lesser amounts of zircon and opaque minerals. Very coarse (8 to 16 inch [20-40 cm] diameter clasts), lithic-rich portions resemble the caldera-related "mesobreccia" described by Lipman (1976), and weather to form cobble- and boulder-strewn slopes, with little exposed matrix. Five modal analyses (figure 4 and appendix A) indicate that the lithic-crystal, ash-flow tuff member is a dacite.

The lithic-crystal, ash-flow tuff member show the effects of argillic alteration in most exposures. Based on x-ray diffraction data, pumice clasts alter to an illite-group clay (possibly celadonite) and minor kaolinite. Plagioclase crystals alter to kaolinite + calcite. Biotite alters to montmorillonite + calcite. The matrix of the tuff alters to the above-mentioned clay minerals and calcite, and can contain pyrite, or iron oxides and sulfates.

The contact between the lithic-crystal, ash-flow tuff member and underlying units has been identified at two localities. Near the type locality, drill-hole cuttings show that the tuff overlies Paleozoic limestone (American Gold Minerals Corporation, unpublished data). In the center of the quadrangle, the tuff overlies the unnamed conglomerate (TKc). Contacts between the lithic-crystal, ash-flow tuff member and overlying units are poorly exposed.

The age of the lithic-crystal, ash-flow tuff member has not been directly determined by radiometric dating. We interpret the age of the lithic-crystal, ash-flow tuff member to be about the same as the megabreccia member because an apparently poorly welded equivalent of lithic-crystal, ash-flow tuff forms the matrix of megabreccia. We bracket the age of the megabreccia member between about 36.5 and 39.4 million years old (see below).

The maximum exposed thickness of the lithic-crystal, ash-flow tuff member is about 60 feet (20 m).

Megabreccia member (Tdom): The megabreccia member consists of clasts of Prospect Mountain Quartzite, Pioche Formation, undifferentiated lower Paleozoic limestone, conglomerate, andesitic lahar, and andesite. Clast sizes range from less than 1 foot to 800 feet (<30 cm to 240 m) in diameter. Most clasts are 10 to 200 feet (3 to 60 m) in diameter. The matrix of the megabreccia member, where exposed, is a poorly welded equivalent of the lithic-crystal, ash-flow tuff member of the Dead Ox Tuff (described above), and was only observed at the reference section for the megabreccia and another locality. At the reference section (NW1/4 SE1/4 SW1/4, section 26, T. 11 S., R. 10 W.), highly altered, poorly exposed, poorly welded tuff occurs between clasts. A thin rind of ash-flow tuff coats the megabreccia clasts at this locality. Another exposure of megabreccia in the SE1/4 NE1/4 NW1/4, section 31, T. 11 S., R. 9 W. contains several low, rubbly outcrops of lithic-crystal, ash-flow tuff that we interpret to be matrix. This exposure is one of the few areas of megabreccia that sits above the highest Lake Bonneville level. We speculate that mantling of megabreccia by lake sediments accounts for the paucity of exposed matrix.

An interesting property of the megabreccia is that nearly all of the quartzite clasts, and some of the limestone clasts, are intensely and pervasively brecciated, while clasts of andesite flow and lahar are not brecciated. Sedimentary clasts in the megabreccia display two types of breccia textures. The first (and most abundant) texture consists of monolithologic, angular, matrix-supported breccia with a fine-grained matrix of comminuted material. Figure 6 shows a typical clast, consisting of a quartzite breccia. This texture indicates that a period of intense and pervasive brecciation affected the quartzite and limestone either during or prior to their incorporation into the megabreccia. The second breccia texture consists of a network of many small fractures and faults, which are restricted to the clasts. Combined with the unbrecciated nature of andesite clasts, these textures could have been produced during thrust faulting, and later incorporated into the megabreccia.

The megabreccia member is cut by a dacite porphyry intrusion (Tdp), and is therefore probably older than 36.49 ± 0.15 Ma (Shubat and Snee, 1992). The megabreccia member is younger than the oldest part of the andesite of Keg Pass, because andesite clasts occur in the megabreccia. Lindsey (1982) reported an age of 39.4 ± 0.7 Ma on samples that are probably from the andesite of Keg Pass.

The megabreccia member unconformably overlies Paleozoic rocks. The upper contact of the unit is not preserved and no complete sections of the megabreccia member are present. The largest exposed thickness of megabreccia is 280 feet (85 m).

Origin of the Dead Ox Tuff: The origin of the megabreccia member of the Dead Ox Tuff is equivocal. The megabreccia member may have originated by one of two processes (or a combination of both): (1) eruption of megabreccia from a vent (Shawe and Snyder, 1988) or (2) collapse of caldera walls during caldera subsidence (Lipman, 1976). We favor the first of these processes, eruption from a vent, because of the textures present in the intensely brecciated clasts of quartzite and limestone, and the fine-grained matrix of "ground-up" clasts (figure 6). We interpret this brecciation to have originated in the subsurface by a process similar to that described by Shawe and Snyder (1988) as deep-level, subvolcanic "explosion-breccia." Nutt and others (1991) describe similar breccias in the Detroit

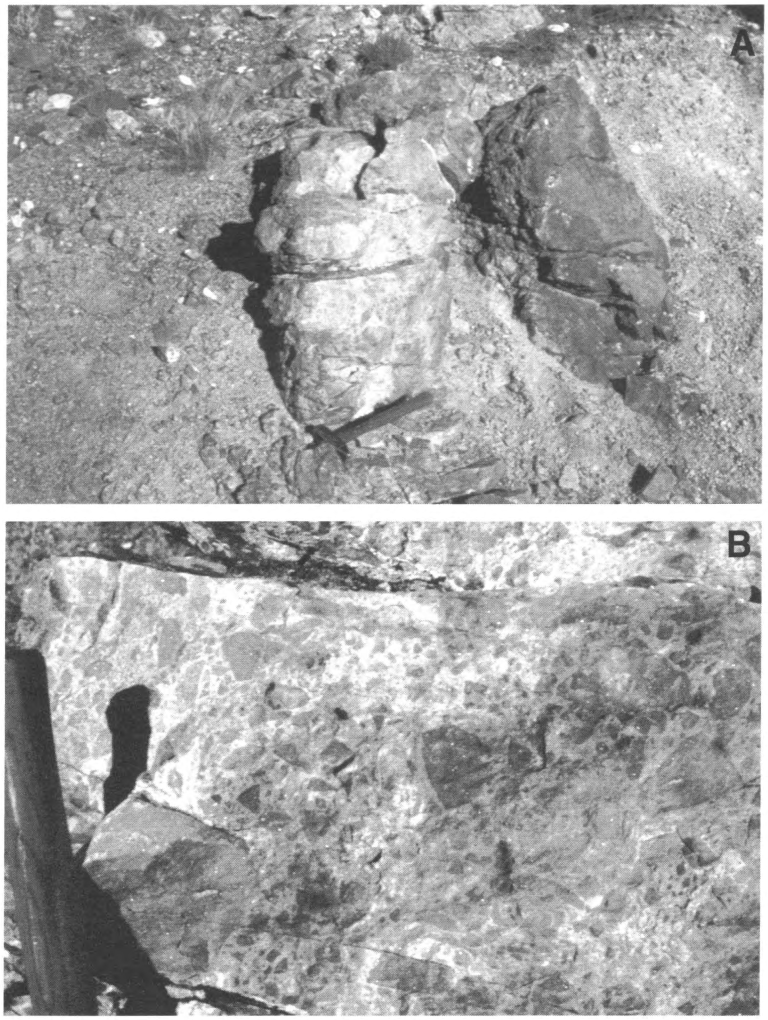


Figure 6. *Megabreccia member of the Dead Ox Tuff at its reference section (NW1/4SE1/4SW1/4, section 26, T. 11 S., R. 10 W.). (A) Exposure showing two megaclasts in the megabreccia, hammer for scale. Block to the left is a pervasively brecciated quartzite megaclast. Block to the right is an unbrecciated andesite megaclast. Matrix is poorly exposed; it consists of light-colored, poorly welded lithic-crystal, ash-flow tuff. (B) Close-up of the pervasively brecciated quartzite megaclast shown above, hammer handle for scale. Breccia in megaclast consists of angular, quartzite clasts (gray) in a fine-grained matrix of comminuted quartzite (light gray).*

district in the nearby Drum Mountains. Nutt and others (1991) interpreted these breccia complexes to have formed in the subvolcanic environment, near the roof of an inferred igneous intrusion. If the intensely brecciated clasts in the megabreccia at Keg Mountain did originate in a subvolcanic environment, then they must have been transported to the surface during eruption of the enclosing Dead Ox tuff. The presence of andesitic lahar clasts in the megabreccia indictes that, if the megabreccia was erupted, the erupted material picked up and incorporated overlying, pre-Dead Ox, volcanic rocks during emplacement, possibly by some venturi effect. We envision an eruption similar to that which produced the Aira caldera in Japan (Aramaki, 1984) as a model for the Dead Ox Tuff eruption. The Aria eruption produced a depression filled with megabreccia and tuff that lacks distinct ring faults.

Several reviewers suggested that the second process, collapse of caldera walls, is an equally feasible origin for the meggabreccia. The "vertical" mixing of Paleozoic and andesitic clasts could occur during collapse or even as a result of venturi effects along the ring fractures. The caldera walls and ring faults would have to be obscured by later eruptions and surficial deposits.

The source of the Dead Ox Tuff cannot be unequivocally identified. However, the presence of huge clasts in the megabreccia member, hundreds of feet in diameter, argues for a nearby vent. Also, the absence of a thick section or wide extent of Dead Ox Tuff argues against a large source caldera. With these constraints in mind, we speculate that the source was an unexposed, ill-defined cauldron, which we name the Flint Spring cauldron (see structure section), located in the north-central part of the quadrangle (figure 7).

Keg Tuff

We propose the formal geologic name, Keg Tuff, for a lithostratigraphic unit of formational rank. We name the unit the Keg Tuff for exposures that cover much of the western part of Keg Mountain. We designate the type locality as the SW1/4 SW1/4 , section 1, T. 12 S., R. 10 W. (in the center of the Keg Pass quadrangle). To date, the Keg Tuff is know only at Keg Mountain and in the Picture Rock Hills. Previous mappers (Erickson, 1963; Shawe, 1972; Staub, 1975; Morris, 1987; Pampeyan, 1989) grouped this unit with the oldest igneous rocks of Keg Mountain (see above).

The Keg Tuff consists of dark-red-brown to black, densely welded, moderately crystal-rich ash-flow tuff of dacitic compositon. A black vitrophyre locally occurs at the base of the Keg Tuff. Vitrophyre also locally occurs above the base, indicating that at least two cooling units are locally present. Abundant bronze-weathering biotite is prominent on surfaces parallel to layering. Phenocrysts are 0.04 to 0.254 inches (1 to 6 mm) in size and consist of plagioclase, biotite, quartz, hornblende, and lesser amounts of pyroxene, zircon, and opaque minerals. The matrix of the unit consists of glass or devitrified glass with locally preserved welded and deformed shard outlines. Many quartz and feldspar phenocrysts are broken or shattered. Biotite crystals are bent. Figure 8 shows the typical textures and mineralogy present in the Keg Tuff. Nine modal analyses (figure 4 and appendix A), and whole-rock chemical analyses of three of these samples and seven other samples (figure 5 and appendix B) indicate that the Keg Tuff is a dacite.

No complete section of the Keg Tuff exists in the Keg Pass quadrangle, however, the lower and upper contacts are exposed at many locations. The Keg Tuff overlies the andesite of Keg Pass over much of Keg Mountain. Irregularities in the contact, as shown in the east half of section 11, T. 12 S., R. 10 W., indicate that the tuff was erupted onto an irregular paleotopographic surface. Map units that overlie the Keg Tuff are the Mt. Laird Tuff (Tml) and the Joy Tuff (Tj). Irregular contacts between the Keg Tuff and overlying units indicate that the overlying units were likewise erupted onto an irregular paleotopographic surface, developed on the Keg Tuff. Map units that intrude the Keg Tuff are the granodiorite porphyry (Tgd), dacite porphyry (Tdp), and rhyolite porphyry (Trp).

Shubat and Snee (1992) dated biotite crystals from the

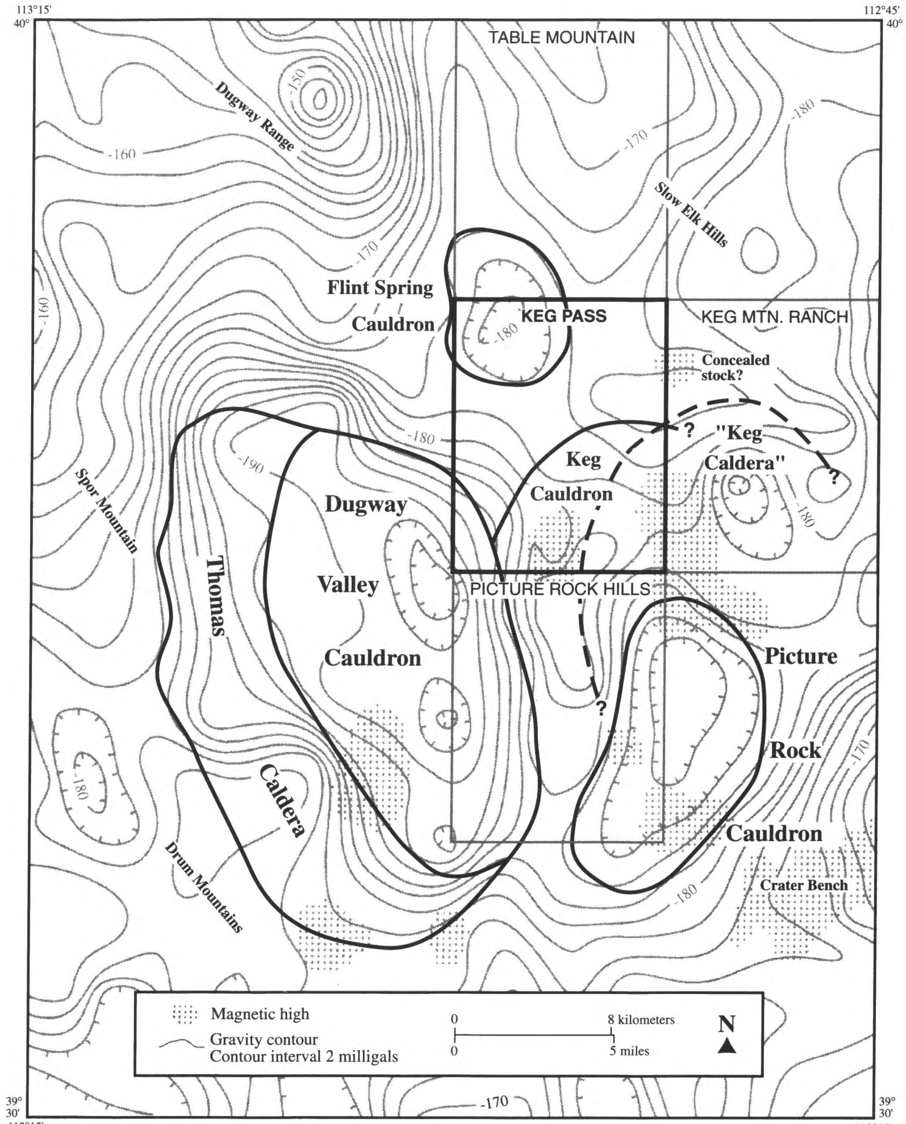


Figure 7. Locations of proposed calderas and cauldrons at Keg Mountain and surrounding areas. Gravity data from Bankey and Cook (1989). Magnetic highs are from data in Kucks (1991). Caldera margins in the Thomas Range from Lindsey (1982).

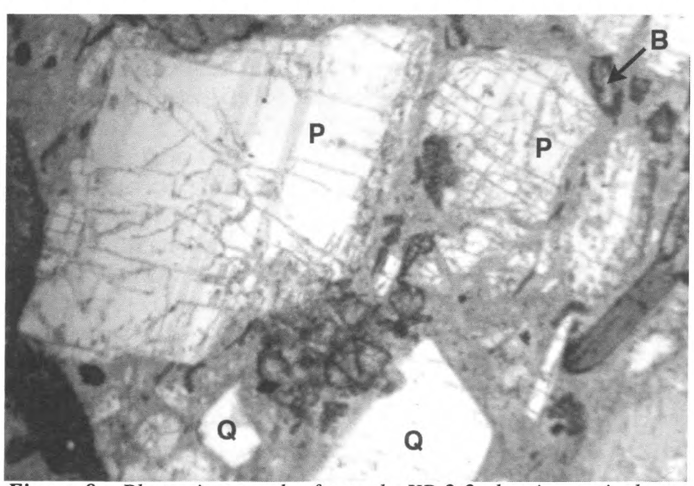


Figure 8. Photomicrograph of sample KP-2-2 showing typical textures and minerals present in the Keg Tuff, crossed nichols. Phenocrysts are quartz (Q), plagioclase (P), and biotite (B). Field of view is 0.16 inches (4 mm).

Keg Tuff at 36.77 ± 0.12 Ma (table 1). We consider this date to be an accurate age for the formation because it is older than the date for the rhyolite porphyry intrusions (Trp; 35.14 ± 0.15 Ma, table 1) and a dacite plug (Tdp; 36.49 ± 0.15 Ma, table 1) that cut the Keg Tuff, and younger than the date for the underlying andesite of Keg Pass (39.4 ± 0.7 Ma; Lindsey, 1982). The date for the Keg Tuff is also slightly older than the overlying Mt. Laird Tuff (Tml; 36.54 ± 0.06 Ma, table 1). However, the differences between the dates for the Keg Tuff, Mt. Laird Tuff, and dacite plug are not statistically significant (Shubat and Snee, 1992).

The restricted distribution of the Keg Tuff, known only at Keg Mountain and the Picture Rock Hills, suggests that it was erupted from a local vent. We propose that it erupted from a poorly defined cauldron, the Keg cauldron (see structure section), with the best defined margin located in the south part of the Keg Pass quadrangle (figure 7). We consider it comagmatic with the granodiorite porphyry (see following section).

No complete section of the Keg Tuff is exposed in the quadrangle. The maximum exposed thickness of the Keg Tuff is 540 feet (165 m), near the type section in the center of the quadrangle. Map relations suggest that there was a period of tilting and erosion after eruption of the Keg Tuff and before eruption of the Mt. Laird Tuff. Thus, the original thickness and distribution of the Keg Tuff may have been greater than what is preserved.

Granodiorite Porphyry (Tgd)

Granodiorite porphyry occurs as a north-south elongate stock in the south-central part of the Keg Pass quadrangle and a plug about 2 miles (3.2 km) to the south in the north-central part of the adjacent Picture Rock Hills quadrangle (Shubat, 1999). We do not give this unit a more formal name because of its limited extent and the small likelihood that it will be correlated with rocks in adjacent ranges. Erickson (1963) and Shawe (1972), in their reconnaissance studies of Keg Mountain, mapped the granodiorite as ignimbrite (tuff) and quartz-latitic, welded ash-flow tuff, respectively. Staub (1975) referred to these rocks as the Keg granodiorite porphyry. Pampeyan (1989) included the stock in the Keg Pass quadrangle in his informally named granodiorite stocks of Keg Mountain.

Granodiorite porphyry consists of light-olive-green to pinkish-green, holocrystalline rock containing large (0.08 to 0.47 inch [2 to 12 mm]) phenocrysts of plagioclase, quartz, biotite, hornblende, and clinopyroxene and lesser amounts of magnetite and zircon set in a fine-grained, subhedral, granular matrix of quartz, plagioclase, and potassium feldspar. Modal analyses of three samples (figure 4 and appendix A) and a whole-rock chemical analysis of one of these samples (figure 5 and appendix B) show these rocks are granodiorite. On figure 4, the dacite compositional field of Le Bas and others (1986) is equivalent to granodiorite for holocrystalline rocks. The unit is pervasively propylitized; plagioclase is altered to clay minerals and calcite, biotite to chlorite and magnetite, and hornblende to chlorite and calcite.

Lindsey (1982) fission-track dated the granodiorite porphyry stock in the Keg Pass quadrangle at 36.6 ± 1.6 Ma. This date agrees well with relationships observed in the field; granodiorite porphyry intrudes the 36.77 ± 0.12 Ma (table 1) Keg Tuff (Tk) and is cut by 35.14 ± 0.15 Ma (table 1) rhyolite porphyry dikes and plugs (Trp).

Because of similarities in whole-rock chemical composition (figure 5, appendix B), age (table 1), and spatial distribution, we consider the granodiorite porphyry to be comagmatic with the Keg Tuff. The stock in the south-central part of the Keg Pass quadrangle may have been intruded into the center of the Keg cauldron (see structure section) after eruption of the Keg Tuff. Modal analyses of Keg Tuff and granodiorite porphyry are different (figure 4, appendix A) because alkali feldspar is in the fine-grained matrix of the Keg Tuff, only counted as matrix, rather than being in phenocrysts.

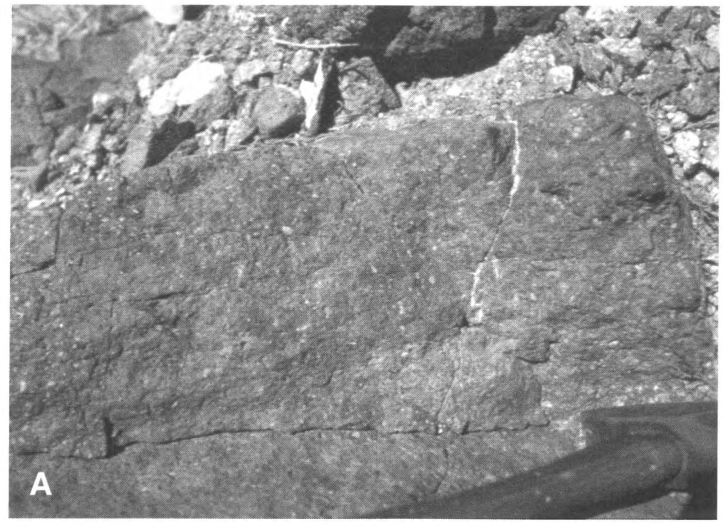
Mt. Laird Tuff (Tml)

Lindsey (1979) named the Mt. Laird Tuff for exposures near Mt. Laird in the nearby Thomas Range, and reported its presence at Keg Mountain. Shawe (1972) mapped a quartz-latitic, welded, ash-flow tuff at Keg Mountain, some of which corresponds to areas we mapped as Mt. Laird Tuff. Much of the area shown as latitic flows of Keg Mountain by Pampeyan (1989) corresponds to areas we mapped as Mt. Laird Tuff.

Mt. Laird Tuff consists of lavender, pale-green, dark-green, and brown, moderately welded, ash-flow tuff, tuff-breccia, lapilli-tuff of dacitic composition. Probable lava flows and hypabyssal intrusions with similar appearance and dacitic composition were mapped with the tuffs as Mt. Laird Tuff in the Keg Pass and Keg Mtn. Ranch quadrangles. A distinctive feature of the Mt. Laird Tuff, and probable lavas and intrusions, is the presence of abundant, large (0.08 to 0.47 inch [2 to 12 mm]) phenocrysts of white plagioclase. Other phenocrysts present in the rock are hornblende, biotite, resorbed quartz, clinopyroxene, magnetite, large sphene, and zircon. Ash-flow tuff textures are often difficult to distinguish in the field, but are easily seen in thin section. In thin section, observable ash-flow textures consist of shattered plagioclase phenocrysts, and ragged and bent biotite grains. Vitrophyre locally occurs at the base of the unit.

A volumetrically minor facies is accretionary lapilli, block tuff (figure 9A) with a distinctive black, aphyric matrix that also contains the accretionary lapilli (figure 9B, sample KP-5-22). Accretionary lapilli may form as moist aggregates of ash in eruption clouds, or by rain that falls through dry eruption clouds (Fisher and Schmincke, 1984).

Many samples show moderate propylitic alteration. The matrix, originally glassy, is altered to a mixture of fine-grained montmorillonite and silica, with zeolite minerals filling voids (unpublished x-ray diffraction data). Plagioclase is locally altered to calcite and clay minerals. Ferromagnesian minerals are locally altered to chlorite, epidote, calcite, and magnetite.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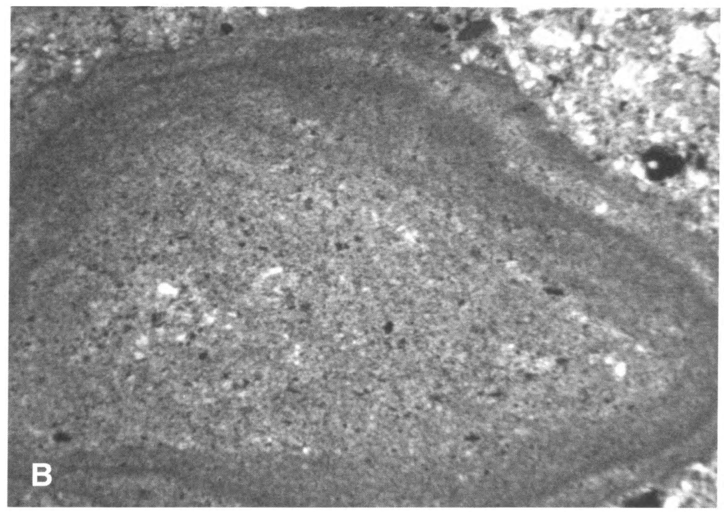
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Figure 9. *Lithologies present in the Mt. Laird Tuff in the east part of the Keg Pass quadrangle. (A) Exposure of the tuff-breccia facies of the Mt. Laird Tuff in the northeast part of quadrangle, hammer for scale. Clasts are less than 0.4 to 8 inches (<1 to 20 cm) in diameter and consist of the ash-flow tuff facies of the Mt. Laird Tuff. The matrix consists of poorly to moderately welded tuff. (B) Photomicrograph of an accretionary lapillus from the accretionary lapilli, block-tuff facies of the Mt. Laird Tuff, sample KP-5-22 from east-central edge of quadrangle. Lapillus consists of fine crystal fragments and ash. Field of view is 0.16 inches (4 mm).*

Modal analyses of 25 samples (figure 4 and appendix A) indicate that, based on phenocryst content, these rocks would be named andesite. Figure 5, however, shows that whole-rock chemical analyses of eight of these and eight other samples (appendix B) mostly plot within the dacite compositional field of Le Bas and others (1986). Classification as a dacite is more compatible with the ash-flow tuff origin and high silica content of the rocks.

Shubat and Snee (1992) $^{40}Ar/^{39}Ar$ dated hornblende and biotite crystals from two different samples of the Mt. Laird Tuff and obtained an average age of 36.54 ± 0.06 Ma (table 1). Biotite from one of these samples (NKM-21-12, table 1) yielded a K-Ar date of 37.1 ± 1.5 Ma (Geochron Laboratories). Lindsey (1982) reported a fission-track date of 36.4 ± 1.6 Ma for the Mt. Laird Tuff in the Drum Mountains, but because of field relations and dates on other units he considered its true age to be about 39 million years old. We consider the true age of the Mt. Laird Tuff to be close to 36.54 ± 0.06 Ma because of the consistency of this date with dates (table 1) for the underlying Keg Tuff (Tk; 36.77 ± 0.12 Ma), the overlying Joy Tuff (Tj; 34.88 ± 0.06 Ma), and rhyolite porphyry intrusions (Trp; 35.14 ± 0.15 Ma) that cut the Mt Laird.

The Mt. Laird Tuff, and probable flows and intrusions mapped with the Mt. Laird, closely resemble the dacite porphyry unit (Tdp) described below in many ways. The two map units are similar in hand sample appearance, spatial distribution, modal analyses (figure 4), chemical analyses (figure 5), and nearly identical in age (table 1). For these reasons we consider the Mt. Laird Tuff, probable lavas and intrusions, and dacite porphyry to be comagmatic. The difference between the two map units is: rock bodies mapped as dacite porphyry are clearly intrusive in origin. A possible concealed pluton related to dacite porphyry and Mt. Laird lavas and intrusions is noted in the section on dacite porphyry.

Lindsey (1982) associated the eruption of the Mt. Laird Tuff with collapse of the Thomas caldera (see structure section; figure 7). Over most of the Keg Pass quadrangle, the unit appears to be outflow from the Thomas caldera. Evidence supporting this interpretation is that, where top and bottom contacts are exposed, the unit is thin (exposed thickness ≤220 feet [≤67 m]).

Vents for lavas, and possibly some related tuffs, mapped with the Mt. Laird Tuff may be present on the northeast margin of the Keg Pass (sections 17 and 20, T. 11 S., R. 9 W.) and west-central margin of the Keg Mtn. Ranch (section 33, T. 11 S., R. 9 W., and section 4, T. 12 S., R. 9 W.) quadrangles (figure 3). Vent(?) facies rocks extend west into the Keg Pass quadrangle and east into Keg Mtn. Ranch quadrangle from these areas. Evidence for vents in these areas are coarse fragmental textures in adjacent (related?) tuffs and an accretionary-lapilli block-tuff facies, steeply dipping layering, alteration, probable hypabyssal intrusions, and pebble dikes (Tpd) containing Mt. Laird clasts (this report; Shubat and others, 1999). Extensive petrography, precise and accurate dating, and more detailed mapping are required to separate these lithologies and their vents from typical Mt. Laird Tuff.

No complete section of the Mt. Laird Tuff is exposed in the Keg Pass quadrangle; the maximum exposed thickness of the Mt. Laird Tuff is 220 feet (67 m).

Dacite Porphyry (Tdp)

Dacite porphyry occurs as several olive-green, small, hypabyssal plugs, less than 3,000 feet (900 m) in diameter, located in the center of the Keg Pass quadrangle. We do not give this unit a more formal name because of its limited extent in the quadrangle. Rocks mapped as dacite porphyry in this study probably correlate with similar rocks in the Thomas Range that Lindsey (1979) informally named "intrusive porphyry" and included within the definition of the Mt. Laird Tuff. Previous workers that mapped at Keg Mountain did not recognize this unit.

Dacite porphyry contains abundant large (0.08 to 0.4 inches [2 to 10 mm]) phenocrysts of plagioclase, quartz, biotite, hornblende, and magnetite set in a matrix of plagioclase, quartz, and sanidine microphenocrysts and aphanitic material. Modal analyses of four samples (figure 4 and appendix A) indicate that, based on phenocryst content, these rocks should by named andesite. Figure 5, however, shows that whole-rock chemical analyses of one of these samples and two other samples of the unit (appendix B) plot within the dacite compositional field of Le Bas and others (1986). We prefer the name dacite as opposed to andesite because of the high silica content of the rocks. The unit is pervasively propylitized in the Keg Pass quadrangle. Plagioclase is altered to clay minerals and calcite, biotite to chlorite and magnetite, and hornblende to chlorite and calcite.

Shubat and Snee (1992) $^{40}Ar/^{39}Ar$ dated biotite from the unit at 36.49 ± 0.15 Ma (table 1). This date closely corresponds to our date of 36.2 ± 1.4 Ma (K-Ar on biotite, Geochron Laboratories). For the reasons given above, we consider the dacite porphyry and the Mt. Laird Tuff, and probable lavas and intrusions, to be comagmatic.

Regional aeromagnetic data (Kucks, 1991) show a circular, high-amplitude magnetic high (with a paired dipole low to the north) that straddles the northern part of the boundary between the Keg Pass and Keg Mtn. Ranch quadrangles (figure 7). We interpret this anomaly as representing a concealed dacite porphyry stock, because several dacite porphyry plugs are present in the Keg Mountains and the highs proximity to the possible "Mt. Laird" lava vents described above (figure 3). Audio-magnetotelluric (AMT) resistivity data support this interpretation (D.L. Campbell, verbal communication, 1990). Dacite porphyry plugs are of economic interest because of the presence of anomalous amounts of gold in the argillic/pyritic alteration halo around some of the intrusions (see metallic minerals section).

Two lines of evidence suggest that another concealed pluton underlies an area just south of Keg Pass. This pluton is probably related to intermediate composition igneous rocks like the possible stock discussed in the previous paragraph. First, deep resistivity audio-magnetotelluric (AMT) soundings collected along a north-south profile across Keg Mountain (Campbell and Visnyei, 1989) show a resistive body at depth beneath the Keg Pass area that has a resistivity signature (>200 ohm-meters) typical for many igneous rocks in the region (D. Campbell, verbal communication, 1990). Second, regional aeromagnetic data (Kucks, 1991) show a high-amplitude magnetic ridge extending from Keg Pass to a point about 5 miles (8 km) to the south (figure 7). This magnetic signature is consistent with many known intermediate intrusions in the Deep Creek-Tintic belt (Stewart and others, 1977). This concealed magnetic and resistive body might alternatively be due to other intermediate composition rocks, in particular the Keg Tuff and related granodiorite porphyry, or the andesite of Keg Pass.

Pebble Dike (Tpd)

A pebble dike or pipe occurs about 3,500 feet (1,070 m) north of Keg Pass (center W$\frac{1}{2}$ NE$\frac{1}{4}$ section 8, T. 12 S., R. 9 W.). The exposure is small, only 100-foot (30 m) diameter, and is entirely within andesite of Keg Pass (Ta). We interpret the unit as a pipe because of this circular exposure. The pipe contains argillized and iron-stained clasts of volcanic rocks, Paleozoic rocks, and intrusive rocks. The matrix is not well exposed. The pipe cuts the andesite of Keg Pass (Ta)(39.4 ± 0.7 Ma, table 1) indicating the maximum age of the unit. This pebble pipe is similar to two pebble dikes located in the adjacent Keg Mtn. Ranch quadrangle (section 33, T. 11 S., R. 9 W. and section 4, T. 12 S., R. 9 W.), one of which cuts the Mt. Laird Tuff (Tml)(36.54 ± 0.6 Ma, table 1).

Quartz Monzonite (Tqm)

Quartz monzonite occurs as one or two plugs, with exposures less than 2,000 feet (610 m) in diameter, in the central part of the Keg Pass quadrangle (section 2, T. 12 S., R. 10 W.). We do not give this unit a more formal name because of its limited extent and the small likelihood that it will be correlated with rocks in adjacent ranges. Previous workers that mapped at Keg Mountain did not recognize this unit.

Quartz monzonite is a gray, rusty-weathering, porphyritic rock containing phenocrysts (0.01 to 0.4 inch [0.3 to 10 mm]) of plagioclase, biotite, quartz, hornblende, potassium feldspar, magnetite, and zircon set in a fine-grained matrix of potassium feldspar and quartz. The rock contains sparse dark-green xenoliths. A modal analysis of the phenocrysts in the rock plot in the quartz diorite field of Streckeisen (1976). But when the matrix minerals are tallied, the modal analysis (appendix A) plots in the granite field of Streckeisen (1976)(figure 4). Figure 5 shows that a whole-rock analysis of the same sample (appendix B) plots within the dacite (granodiorite) compositional field of Le Bas and others (1986). Given these differences, we have chosen to retain the name we used in the field, quartz monzonite.

Quartz monzonite is locally argillized, silicified, and pyritically altered. Plagioclase is altered to calcite + clays and hornblende to chlorite + calcite. Potassium feldspar and biotite crystals are mostly unaltered. Faint thin silica overgrowths occur on quartz phenocrysts. Margins of the intrusions show strong pyritic alteration.

The age of quartz monzonite is poorly constrained. It has not been dated and field relations only show that it is younger than the Mt. Laird Tuff (Tml)(36.54 ± 0.06 Ma, table 1) and is probably older than the Topaz Mountain Rhyolite (6 to 8 million years old).

Joy Tuff (Tj)

Lindsey (1979) named the Joy Tuff for exposures near the Joy townsite in the nearby northern Drum Mountains and identified two informal members. Only the lower, crystal tuff member is present at Keg Mountain.

Erickson (1963) first recognized the presence of rhyolitic ash-flow tuff at Keg Mountain. Shawe (1972) refined the work by Erickson (1963). Some of the rhyolitic, welded, ash-flow tuff mapped by Shawe (1972) corresponds to areas we mapped as Joy Tuff. Staub (1975) mapped an informal "Red Mountain Crystal Tuff" unit in the adjacent Picture Rock Hills quadrangle that, in part, correlates with the Joy Tuff. Lindsey (1979) first reported the presence of Joy Tuff in the southwestern part of Keg Mountain. Some of the area shown as Joy Tuff at Keg Mountain by Pampeyan (1989) corresponds to areas we mapped as Joy, Mt. Laird, and Dell Tuff.

Joy Tuff consists of red-brown to pink, distinctly red-weathering, moderately to densely welded, rhyolitic ash-flow tuff. Scattered exposures are present in the south and west parts of the quadrangle. A black vitrophyre locally occurs at the base of the unit and is overlain by a black, fiamme-rich zone. Variations in the degree of welding occur in the adjacent Picture Rock Hills quadrangle. The Joy Tuff contains abundant, 0.04 to 0.31 inch (1 to 8 mm) phenocrysts of quartz, sanidine, plagioclase, and biotite, and trace amounts of sphene, zircon, and magnetite. The unit contains as much as 14 percent lithic clasts that consist of volcanic, igneous, and sedimentary rocks. Modal analyses (figure 4 and appendix A) and whole-rock chemical analyses of the same four samples (figure 5 and appendix B) show that these rocks are mostly rhyolite.

In thin section, many ash-flow tuff textures are well displayed. Most large phenocrysts are shattered, bent, or broken. Small phenocryst fragments occur as lenses of "crystal hash." Some samples contain flattened, welded, Y-shaped shards in the matrix. The matrix is typically devitrified but is locally glassy. Phenocrysts are unaltered.

Shubat and Snee (1992) $^{40}Ar/^{39}Ar$ dated sanidine and biotite crystals from a sample of basal vitrophyre of the Joy Tuff and obtained an average age of 34.88 ± 0.06 Ma (table 1). This date shows a marked difference with most of the nine fission-track ages reported by Lindsey (1982; range 34.5 ± 1.3 to 39.7 ± 3.4 Ma) that average 38.0 ± 0.7 Ma. We believe the age of the Joy Tuff is close to 34.88 ± 0.06 Ma, because of the greater accuracy of the $^{40}Ar/^{39}Ar$ age-spectrum dating method. Unpublished $^{40}Ar/^{39}Ar$ age-spectrum dates from the type section of the Joy Tuff (C.J. Nutt, verbal communication, 1992) confirm the date reported by Shubat and Snee (1992), and all are consistent with the observation that Joy Tuff overlies Mt. Laird Tuff (Tml). The date by Shubat and Snee (1992) is nearly identical with the date for rhyolite porphyry (Trp)(34.14 ± 0.15 Ma, table 1). For this and other reasons presented in the section on rhyolite porphyry, we consider the Joy Tuff to be comagmatic with the rhyolite porphyry.

Lindsey (1982) believed the source of the Joy Tuff to be the Dugway Valley cauldron, located between Keg Mountain and Topaz Mountain (figure 7; see structure section). The small thickness of the Joy Tuff in the Keg Pass quadrangle suggests that it is outflow from the cauldron. It is possible, however, that the Joy Tuff in the quadrangle was deeply eroded and was once much thicker.

No complete section of the Joy Tuff is exposed in the quadrangle; the maximum exposed thickness of the Joy Tuff is 80 feet (24 m). In the adjacent Picture Rock Hills quadrangle, the maximum exposed thickness is 540 feet (160 m) thick, with more than 3,000 feet (>915 m) encountered in boreholes in the southwest part of the quadrangle (Shubat, 1999).

Rhyolite Porphyry (Trp)

Rhyolite porphyry occurs as many small, hypabyssal dikes and elongate plugs that form at least two linear, subparallel, north- to east-trending zones described in the structure section. We do not give this unit a more formal name because of its limited extent in the quadrangle and the small likelihood that it will be correlated with rocks in adjacent ranges.

Shawe (1972) first recognized these intrusions and called them intrusive quartz latite. Lindsey and others (1975) depicted some of these intrusions. Morris (1987) mapped the intrusions in greater detail. Pampeyan (1989) informally named the unit the quartz latite stocks of Keg Mountain.

Rhyolite porphyry consists of pale-gray to pink, light-tan weathering rhyolite porphyry with large (up to 0.4 inches [1 cm]) phenocrysts of sanidine, quartz, plagioclase, and biotite and lesser amounts of zircon and opaque mineral phenocrysts. The matrix consists of aphanitic crystallites, resembling devitrified glass, that are locally altered to zeolite minerals. A variety of textures are present in the rock. Near the margins of the intrusions, the rock is nearly aphyric, only containing sparse sanidine crystals, and has a platy parting. This parting grades laterally into massive rhyolite porphyry within 10 feet (3 m) of the contact. In some exposures, rhyolite porphyry has a "filter pressed" texture (see Best, 1982) that consists of large, cracked crystals of quartz, orthoclase, and plagioclase with minor, interstitial matrix. Modal analyses of nine samples (figure 4 and appendix A) and whole-rock chemical analyses of six of these and four other samples (figure 5 and appendix B) show these rocks are mostly rhyolite.

Shubat and Snee (1992) $^{40}Ar/^{39}Ar$ age-spectrum dated sanidine and biotite from one of these plugs in the Keg Mtn. Ranch quadrangle and obtained an average age of 35.14 ± 0.15 Ma (table 1). Lindsey and others (1975) fission-track dated a sample (DRS-282-63) of an elongate rhyolite porphyry plug in the Keg Pass quadrangle at 30.8 ± 1.8 Ma. We interpret the true age of the rhyolite porphyry intrusions to be near the date reported by Shubat and Snee (1992) because of the greater accuracy of the $^{40}Ar/^{39}Ar$ age-spectrum dating method.

The rhyolite porphyry intrusions and the Joy Tuff are similar in many ways. The two units have similar phenocryst assemblages (figure 4, appendix A) and chemical compositions (figure 5, appendix B). Most importantly, they have nearly identical ages (table 1). For these reasons we consider the rhyolite porphyry to be the hypabyssal, comagmatic equivalent of the Joy Tuff.

Dell Tuff (Td)

Lindsey (1979) formally named the Dell Tuff for exposures near The Dell in the nearby Thomas Range and reported the presence of the unit in the Keg Pass quadrangle. Staatz and Carr (1964) first identified the unit in the Thomas Range and called it a quartz-sanidine crystal tuff. At Keg Mountain, Erickson (1963) mapped Dell Tuff as part of his informal "Keg Mountain Ignimbrite." Shawe (1972) mapped a rhyolitic, welded, ash-flow tuff at Keg Mountain that in part corresponds to the Dell Tuff. Part of the area mapped by Morris (1987) as the Dell Tuff corresponds to areas we mapped as the Dell Tuff. Plavidal (1987) incompletely depicted the Dell Tuff in the Keg Mtn. Ranch quadrangle. Pampeyan (1989) showed the Dell Tuff as the Joy Tuff.

The Dell Tuff is a pink to tan, poorly to moderately welded, crystal-rich, rhyolitic ash-flow tuff exposed in the southeast quarter of the quadrangle. The Dell Tuff contains abundant phenocrysts of quartz, sanidine, plagioclase, and biotite that range in size from 0.08 to 0.4 inch (2 to 10 mm). Trace amounts of hornblende, opaque minerals, zircon, and large sphene crystals are also present. Phenocrysts are shattered, broken, and bent. The matrix consists of glass that is locally devitrified and spherulitic. Shard structures are preserved in the matrix. Lithic fragments (volcanic) constitute as much as 19 percent of the rock, but usually less than 1 percent. The rock is unaltered. Modal analyses of five samples (figure 4 and appendix A), and whole-rock chemical analyses of three of these and two other samples (figure 5 and appendix B) show these rocks are rhyolite.

Lindsey and others (1975) fission-track dated two samples from the Keg Pass area, and obtained ages of 32.5 ± 1.6, 33.6 ± 1.8, and 33.8 ± 1.3 Ma (as corrected in Lindsey, 1982). Lindsey (1982) reported an average age of 32.0 ± 0.6 Ma for the formation in the Thomas Range and Keg Mountain. These dates are consistent with field relations, because the Dell Tuff overlies 35.14 ± 0.15 Ma rhyolite porphyry intrusions (Trp) and is overlain by Topaz Mountain Rhyolite (6 to 8 million years old).

Paleomagnetic work (J.L. Hanna, University of Vermont, verbal communication, 1989; Gutscher, 1989) showed that the Dell Tuff at the type locality in the Thomas Range has a normal magnetic polarity and that the Dell Tuff at Keg Pass has a reverse polarity, indicating that the Dell Tuff consists of at least two cooling units. Multiple cooling units, however, were not observed in the field.

The source of the Dell Tuff has not been found. Based on extent and thickness, Lindsey (1982) speculated that the source caldera should lie in or near Keg Mountain or the Thomas Range. The speculative Picture Rock cauldron is shown on figure 7 (see structure section), and was noted by Shubat (1999) as a possible source for the Dell Tuff.

The greatest thickness of Dell Tuff at Keg Mountain is in the Keg Mtn. Ranch quadrangle, where it is 600 feet (180 m) thick. In the Keg Pass quadrangle, its thickness ranges from 0 to 350 feet (0 to 110 m). It unconformably overlies older rocks and is unconformably overlain by the Topaz Mountain Rhyolite.

Topaz Mountain Rhyolite

Erickson (1963) first described and named (informally) the Topaz Mountain Rhyolite and underlying Topaz Mountain Tuff. Lindsey (1979) redefined and formally named the unit, including both lithologies in the Topaz Mountain Rhyolite. Lindsey (1979) identified two informal members: (1) alkali rhyolite and vitrophyre, and (2) stratified tuff. We follow the usage proposed by Lindsey (1979) in this report, but do not use the term "alkali" because alkali is a modifier that has more than one meaning. Many previous workers recognized and mapped the Topaz Mountain Rhyolite at Keg Mountain (Erickson, 1963; Shawe, 1972; Staub, 1975; Morris, 1987; Plavidal, 1987; Pampeyan, 1989). Staub (1975) mapped Topaz Mountain Rhyolite flows, domes and intrusions, and tuff in the Picture Rock Hills quadrangle, informally naming most of them the "Keg Mountains Rhyolite and Tuff." This, unfortunately, was approximately the name given by Shawe (1972) (rhyolite of Keg Mountains) for a different unit in the Keg Mtn. Ranch quadrangle. Following Shawe (1972), Morris (1987) distinguished two Miocene rhyolite units, the older rhyolite of Keg Mountain and the younger Topaz Mountain Rhyolite. Pampeyan (1989) introduced a new informal nomenclature for these

Miocene rhyolites that we do not use.

We mapped two informal members of the Topaz Mountain Rhyolite: (1) stratified tuff; and (2) rhyolite flows, domes, and intrusions. This subdivision is consistent with the mapping by Lindsey (1979; 1982). In general, stratified tuff underlies rhyolite flows and domes. In many areas, however, stratified tuff occurs as discontinuous, wedge-shaped intercalations between flows. Stratified tuff was probably, in part, explosively erupted from the same vents as, and possibly just before, the rhyolite flows and domes. Some stratified tuff was also reworked by water.

Two types of vitrophyre are present in the Topaz Mountain Rhyolite. In many exposures, a black vitrophyre (typically a ledge-forming rock) occurs at the base of flows and represents chilled flow rock. In other exposures, however, the stratified tuff beneath a flow has been fused to form a vitrophyre. This rock, called "fused tuff" by Christiansen and Lipman (1966), contains black, collapsed and fused pumice clasts and that resemble fiamme. This fused tuff has a glassy texture and strongly resembles ash-flow tuff.

Stratified tuff (Ttmt): Stratified tuff consists of pale-tan to orange, very thick- to thin-bedded, nonwelded, lithic-rich rhyolitic tuff and volcanic sandstone, and local tuff breccia. The unit contains a variety of pyroclastic material, including volcanic rock fragments (flows, tuff, and welded tuff), abundant pumice clasts, and sparse crystal fragments in an ash matrix. Size sorting also varies. Beds of mostly ash with some lithic and pumice clasts are common. In these poorly sorted beds, the clasts are typically much larger than the ash matrix. Other beds mostly contain roughly sand-sized (0.02 to 0.12 inch [0.5 to 3 mm]) pyroclasts. The unit was deposited from air-fall, ash-flow, and ground-surge eruptions at Spor Mountain (Bikun, 1980). At Keg Mountain and the Picture Rock Hills, this tuff consists of (1) water-lain and air-fall deposits (Lindsey, 1979), (2) vent-clearing deposits, includes tuff breccias and poorly sorted, ground-surge deposits (J.K. King, verbal communication, 1995), and (3) reportedly as ash-flow deposits (Staub, 1975). The unit is extensively argillized (montmorillonite), zeolitized, and feldspathically altered throughout Keg Mountain (Lindsey and others, 1974; Lindsey, 1975). Lindsey (1975) showed that glass in the unit was progressively altered, first to clinoptilolite and then to potassium feldspar.

Beds of stratified tuff occur as discontinuous lenses beneath many rhyolite flows. Beds range in thickness from 0 to 140 feet (43 m).

Rhyolite flows, domes, and intrusions (Ttm): This unit consists of flows, domes, and dike-like, shallow intrusions of white, gray, and purple rhyolite containing sparse (10 to 15 percent), small (0.08 inch [2 mm]) phenocrysts of quartz and sanidine and lesser amounts of plagioclase, biotite, and opaque mineral phenocrysts. The matrix consists of devitrified glass, and contains irregular voids that constitute as much as 12 percent of the rock. Black to brown vitrophyre occurs at the base of some flows and domes. Breccias with stratified tuff and rhyolite flow clasts in a rhyolite flow matrix are locally exposed at vents (J.K. King, verbal communication, 1995). Staub (1975) described basal flow breccias with the same types of clasts. Rare topaz crystals occur in cavities. In addition to topaz, Staub (1975) identified small crystals of hematite, quartz, bixbyite, and pseudobrookite that line cavities. Two modal analyses (appendix A), and chemical analyses of one of these samples and one other sample (appendix B) from this unit plot as quartz-rich rhyolite, dacite (figure 4), and rhyolite (figure 5).

Flows and domes of rhyolite were probably erupted from several local vents. In some cases continuous exposures can be followed that show flows at higher elevations changing to dike-like intrusive bodies at lower elevations. Most dike-like bodies and eruptive dome/flow complexes have north-northwest trends, forming several lineaments in the quadrangle (see structure section).

Lindsey and others (1975) reported fission-track dates of 7.8 ± 0.6 and 8.2 ± 0.5 Ma for the Topaz Mountain Rhyolite at Keg Mountain. Lindsey (1982) reported an average date of 6.3 ± 0.1 Ma for five samples of Topaz Mountain Rhyolite from Topaz Mountain. Staub (1975) noted that at least two eruptive episodes occurred in the Picture Rock Hills quadrangle (her Keg Mountain Rhyolite). Plavidal (1987) reported K-Ar dates of 6.7 ± 0.3 and 6.9 ± 0.3 Ma for the rhyolite of Keg Mountain, which underlies and is compositionally gradational with the Topaz Mountain Rhyolite in the Keg Mtn. Ranch quadrangle (Plavidal, 1987). We believe that the true age of the Topaz Mountain Rhyolite at Keg Mountain is close to the date of 6.3 ± 0.1 Ma reported by Lindsey (1982), because it overlies the rhyolite of Keg Mountain.

No complete section of flows of Topaz Mountain Rhyolite is present in the quadrangle. Its maximum exposed thickness is 590 feet (180 m). Field relations in the Keg Mtn. Ranch quadrangle indicate that it was deposited on a paleotopographic surface consisting of gently rolling hills. Staub (1975) noted that a major unconformity, period of erosion, separates the Miocene igneous rocks (Topaz Mountain Rhyolite) from older igneous rocks.

Quaternary and Tertiary

Quaternary and Tertiary deposits were classified primarily by their environment of deposition or origin as interpreted from geomorphic expression. Within each environment/origin, units were subdivided based on grain size (texture) and composition. Unit ages were based on surface morphology, carbonate and soil development, degree of consolidation, and stratigraphic relationships, where exposed. Map-unit symbols reflect this classification scheme. Capital letters show the general age (Q = Quaternary, T = Tertiary); next, lowercase letter(s) show the depositional environment; these are followed by lowercase letters that show grain size and composition subdivision when necessary. Letters (o = older, y = younger) or a subscripted number at the end of the symbol show the relative age of the unit, with numbers increasing for older deposits. One "stacked unit" is shown on the map (Qlg/QTaf), where thin, discontinuous cover of lacustrine gravel (Qlg) mantles older alluvial fan deposits (QTaf). The color and pattern on the map (plates 1 and 2) indicate the most pervasive unit (QTaf).

Quaternary and Tertiary deposits in the Keg Mtn. Ranch quadrangle include alluvial-fan deposits, stream alluvium, colluvium, alluvium plus colluvium, undivided lacustrine and alluvial deposits, and lacustrine deposits.

Older Alluvial-Fan Deposits (QTaf)

Coarse-grained older alluvial-fan deposits of probable early Pleistocene age, or perhaps Pliocene age (see Christenson and Purcell, 1985 for criteria), are present on the west flank of Keg Mountain between the mountains and the Bonneville shoreline (5,221 feet; 1,592 m). The deposits are unconsolidated to semi-consolidated, poorly sorted and consist of clasts of all sizes, from clay to boulders greater than 3 feet (1 m) in diameter. Deposits are undergoing erosion and original fan surfaces have been degraded, forming a series of finger-like ridges (commonly termed whalebacks or ballenas) up to 60 feet (18 m) above modern streams. These older alluvial fans are now beheaded or detached from their original source areas as the less erosion-resistant volcanic rock of the mountain front is removed. The surface of the deposit is marked by a lag concentrate of the larger clasts. Deposits are at least 60 feet (18 m) thick, and perhaps more, where exposed. Similar-age deposits of unknown thickness may underlie lacustrine deposits along the northern and western edges of the quadrangle. Where the deposit has been eroded and reworked by Lake Bonneville (stacked unit Qlg/QTaf), the surface is strewn with large, weathered, case-hardened boulders.

Quaternary

Intermediate-Age Alluvial-Fan Deposits (Qaf_2)

Alluvial-fan deposits of middle to late Pleistocene age are present above the Bonneville shoreline (5,221 feet [1,592 m]) at Keg Mountain. These alluvial-fan deposits predate initial occupation of the Bonneville shoreline 15,000 years ago. Fan surfaces are generally 3 to 20 feet (1 to 6 m) above modern channels, and are inactive and undergoing erosion. Erosion has produced an intricate, parallel to pinnate pattern of gullies. A gradation in morphology (degree of dissection), level, and presumably age is apparent from the youngest of these intermediate-age fans back to the older Quaternary and Tertiary alluvial fans (QTaf). Deposits are poorly stratified, poorly sorted mixtures of clay, silt, sand, pebbles, cobbles, and boulders of both debris-flow and stream-flow origin, and are generally less coarse than adjacent older alluvial-fan deposits (QTaf) at similar mountain-front positions. In mountain-front locations, intermediate-age alluvial-fan deposits are generally less than 20 feet (6 m) thick. They thicken away from the front, however, and similar-age deposits of unknown thickness probably underlie lacustrine deposits in the valleys to the north and west.

Lacustrine Marl (Qlm)

Light-colored, fine-grained, deep-lake or quiet water deposits of marl and lesser clay, silt, and sand, including ostracode- and gastropod-rich layers, are present in the northwest corner of the quadrangle. Deposition occurred in latest Pleistocene time, chiefly while Lake Bonneville occupied the Bonneville shoreline. Exposed thicknesses of up to 6 feet (2 m) are found locally, but total thickness is unknown. These deposits are locally overlain by unmapped thin veneers of lacustrine and alluvial sand and gravel, and eolian sand.

Lacustrine Sand (Qls)

Shore-zone and offshore deposits of sand with lesser clay, silt, and pebbles are found below the Bonneville shoreline and are most extensive in the northern part of the quadrangle between the Bonneville and Provo shorelines. These deposits are of latest Pleistocene age, deposited chiefly while Lake Bonneville occupied the Bonneville shoreline, and may be up to 30 feet (9 m) thick in the zone between the two shorelines. Below the Provo shoreline, these deposits are probably much thinner.

Lacustrine Gravel (Qlg)

Coarse-grained shore-zone deposits, chiefly sand and pebble-sized gravel with cobbles and silt, are usually found just below the Bonneville shoreline. These gravels were deposited as the lake transgressed to and occupied the Bonneville shoreline during latest Pleistocene time. They are generally thin, but may be up to 30 feet (9 m) thick in some barrier beaches.

Colluvium (Qmc)

Poorly sorted colluvium of Pleistocene and Holocene age occurs on steep mountain slopes below rock outcrops. The unit also consists of coarse, angular cobble- and boulder-sized talus, and commonly grades downslope into mixed alluvium and colluvium (Qac). Colluvium may reach thicknesses of 30 feet (9 m) or more near the bases of slopes, but is generally less than 10 feet (3 m) thick.

Alluvium and Colluvium (Qac)

Mixed alluvium and colluvium of Pleistocene and Holocene age occur in first-order drainages, alluviated slopes below colluvium, and in poorly developed alluvial fans. Deposits are generally less than 10 feet (3 m) thick, and are generally poorly sorted clay, silt, sand, pebbles, cobbles, and boulders. The coarsest deposits occur on the steepest slopes and along drainages.

Undifferentiated Lacustrine and Alluvial Deposits (Qla)

Undifferentiated alluvial and lacustrine deposits of latest Pleistocene and Holocene age occur in the zone between the Bonneville (5,221 feet [1,592 m]) and Provo (4,838 feet [1,476 m]) shorelines. These deposits are mostly sand and pebble-sized gravel with cobbles. They include lacustrine deposits that have been partially reworked by post-lacustrine streams and slope wash; pre-lacustrine alluvial-fan deposits that were partially reworked in Lake Bonneville; and alluvial and lacustrine deposits which cannot be differentiated at the map scale. Thickness probably rarely exceeds 10 feet (3 m), although the unit may be underlain by great thicknesses of other unconsolidated alluvial and lacustrine deposits.

Younger Alluvial-Fan Deposits (Qaf_1)

These post-Bonneville alluvial-fan deposits are found principally below the Bonneville shoreline in the northern and western parts of the quadrangle. The fans usually have apices at either the Bonneville or Provo shoreline scarps.

Post-Bonneville fans in general are finer grained than pre-Bonneville fans (QTaf, Qaf_2) and contain mostly sand and gravel, much of it reworked from lake deposits. These fans are generally thin and in their distal parts are commonly a veneer over lake deposits, tapering to a feather edge into the basin. Deposits are thickest near fan apices, but even there they are generally less than 10 feet (3 m) thick.

Eolian Sand (Qes)

Post-Bonneville (Holocene) wind-blown sand is found below the Bonneville shoreline, chiefly in stabilized dunes that are now being eroded. The well-sorted sand is derived from lacustrine deposits, and is most extensive in the northwest corner of the quadrangle, overlying lacustrine marl and sand below the Provo shoreline. Eolian sands are generally less than 10 feet (3 m) thick.

Stream Alluvium (Qal)

Holocene-age stream alluvium is found in modern stream channels, floodplains, and low terraces 3 to 6 feet (1 to 2 m) above channels. Deposits range in composition from chiefly clay, silt, and sand at the north edge of the quadrangle to coarser sand, pebbles, cobbles, and boulders in the mountains and along mountain fronts. Deposits are generally less than 10 feet (3 m) thick.

STRUCTURE

Thrust Faults and Folds

H.T. Morris (written communication, 1986) first reported the presence of a Sevier-age (Cretaceous) thrust fault in the northern Keg Mountain area and Slow Elk Hills, and showed several on his map (Morris, 1987). Our mapping shows that at least two thrust faults are present in the Keg Pass quadrangle. One thrust, possibly the older of the two, places rocks of the Pioche (€pl, €pt) and Howell (€h) Formations over undifferentiated Cambrian carbonate rocks (€l)(plates, cross-section A-A). This thrust is only exposed on the north edge of the quadrangle (sections 12 and 13, T. 11 S., R. 10 W., and section 18, T. 11 S., R. 9 W.). Rocks on either side of the thrust have similar strikes and dips, suggesting that the thrust fault consists of a hanging wall flat over a footwall flat. Thickness variations in both members of the Pioche Formation (in the hanging wall of the thrust) suggest local attenuation of upper-plate rocks near the thrust. The age of the sub-thrust carbonate rocks (€l) is uncertain, so the stratigraphic separation across the thrust may be as little as 600 feet (180 m) or as great as 2,000 feet (610 m).

The other exposed thrust, possibly the younger of the two thrusts, places rocks of the Prospect Mountain Quartzite (€pm) over undifferentiated Cambrian carbonate rocks (€l) and the lower member of the Pioche Formation (€pl) (plates, cross-section B-B´. Thin thrust-bound slivers of the Pioche Formation locally occur between upper-plate quartzite and lower-plate carbonate rocks. At present the thrust is nearly flat-lying and occurs within an elevation range of 5,100 to 5,400 feet (1,555 to 1,647 m) in the northeast quarter of the quadrangle (plate 1). Subsurface data show that the thrust occurs at a depth greater than 1,250 feet (380 m) beneath Dome Hill (figure 3), suggesting that the thrust dips gently to the west. The thrust may have as little as 1,200 feet (360 m) or as much as 6,500 feet (2,000 m) of stratigraphic separation, depending on the age of the sub-thrust carbonate rocks. Brecciation of upper-plate quartzite is pervasive. White calcite veinlets are ubiquitous in lower-plate carbonate rocks and may have been produced by the thrusting event. Local alteration of lower-plate carbonate rocks to jasperoid occurs immediately beneath the thrust. The thrust surface is sharp and well exposed, consisting of a thin (<1.6 inch [4 cm]) cataclasite zone. No ductile deformation was observed in the footwall.

The relationship between these two thrust faults is uncertain; thrust and fold relationships support two possibilities. Construction of restored cross sections suggests that the relationship is not as simple as that of a horse or imbricate splay. One possible history is (1) emplacement of the first thrust, placing the Pioche Formation over carbonate rocks, (2) folding, and (3) emplacement of the second thrust, placing quartzite over carbonate rocks. In this scenario, the second thrust must cut down section through the hanging wall and footwall of the first thrust. The direction of tectonic transport for both thrusts would be to the east. Another possibility is that the thrusts formed as back thrusts with the direction of tectonic transport to the west.

Correlation of the thrust faults mapped at Keg Mountain to regional thrust sheets is uncertain. Based on the general similarities of the Cambrian sections in the House, Dugway, and Drum Mountains, Morris (1983) considered all these ranges to belong to the Wah Wah-Frisco thrust plate and concluded the Wah Wah-Frisco thrust passed beneath Keg Mountain. We concur with Morris because the limited stratigraphic separations across the thrusts at Keg Mountain suggest that neither of the exposed thrusts are the Wah Wah-Frisco thrust.

Folds in undifferentiated Cambrian carbonate rocks (€l), lying beneath the thrusts, occur in the northeastern quarter of the quadrangle. Most of these are small-amplitude (less than 200 feet; 60 m), upright folds that plunge gently to the northeast (see Shubat, 1987). Minor, mesoscopic, smaller than map scale, folds are east vergent (Shubat and Snee, 1992). Calcite veinlets are abundant in the hinge zones of these folds, with sets of veinlets oriented parallel to bedding and subparallel to the axial planes of minor folds.

The largest fold in the quadrangle, a syncline, occurs in the hanging wall of a thrust in the north half of section 13, T. 11 S., R. 10 W. The syncline is west verging, plunges gently to the north, and has an amplitude of about 1,000 feet (300 m). The syncline appears to deform the first (possibly older) thrust described above. Because units separated by the thrust, and presumably the thrust, dip steeply on the east limb of the syncline.

Calderas and Cauldrons

Because the distinction between a caldera and a cauldron is seldom clear in geologic literature, we explicitly define the terms as used in this report; they follow the definitions of Elston (1978). A caldera is a topographic depression on a volcanic edifice, and thus it is a physiographic term. The most common type of caldera is a collapse caldera, formed during volcanic eruptions by the withdrawal of magma from a magma chamber and the subsequent collapse of the chamber's roof. A cauldron is any structure that forms when the roof of a magma chamber subsides into its chamber. The term cauldron thus refers to all volcanic subsidence features. In this report, the term caldera refers to a volcanic subsidence feature that is bound by a well-defined ring fault(s). The term cauldron refers to all other volcanic subsidence features.

Lindsey (1982) was able to document the history of eruptions of the Mt. Laird Tuff and Joy Tuff; and collapse of the Thomas caldera and Dugway Valley cauldron, respectively. In this report we propose that the eruption of the Dead Ox Tuff and Keg Tuff resulted in the collapse of the Flint Spring and Keg cauldrons, respectively, prior to the collapse of the Thomas caldera and Dugway Valley cauldron.

Flint Spring Cauldron

The source of the Dead Ox Tuff is not known, but our interpretation of an eruptive origin (or at least an eruptive component) for the megabreccia member of the Dead Ox Tuff suggests a nearby vent. We formally propose that the Dead Ox Tuff was erupted from the here-named Flint Spring cauldron, located in the northwest part of the quadrangle (figure 7). The cauldron is named for Flint Spring Road which passes just north of megabreccia exposures. Its outline is different than that of the Flint Spring cauldron first proposed by Shubat (1987), though it is the same outline as that of Shubat and Snee (1992). Stoeser (1993) referred to it as the Dead Ox caldron [cauldron]. The term caldera does not apply because of the absence of clearly defined margins. Several lines of evidence support this style of vent: (1) the presence of a gravity low in this area; (2) the absence of a plausible, mappable caldera margin (structural or topographic wall) bounding the megabreccia terrain; (3) the absence of a thick section of Dead Ox Tuff outside the map area; and (4) the lack of recognizable ring and/or radial faults.

As suggested by reviewers, the source could also be a small caldera with concealed margins. Most of the materials in the north half of the quadrangle are younger than the Dead Ox Tuff, and the Cambrian rocks in this area would be in the floor of the caldera. The most easily concealed caldera would be a trapdoor caldera, hinged at the north with the greatest relief at the megabreccia on the south caldera margin.

Keg Cauldron

To date, the Keg Tuff has only been recognized at Keg Mountain, suggesting that it is a locally derived unit. We propose that it was erupted from a cauldron, here formally termed the Keg cauldron after Keg Mountain. The cauldron is centered on the granodiorite porphyry stock in the south-central part of the Keg Pass quadrangle and encompasses the exposures of Keg Tuff (figure 7). This outline is the same as that shown by Shubat and Snee (1992). The term caldera does not apply because of the absence of clearly defined margins.

As defined here, the Keg cauldron outline differs from the "Keg caldera" postulated by Shawe (1972). As suggested by reviewers, Shawe's (1972) "Keg caldera" margin is roughly around a magnetic-high ridge and gravity low, on the southeast flank of the gravity ridge, north and east of our Keg cauldron (figure 7). This geophysically reasonable interpretation would allow the granodiorite stock and plug, and the magnetic-high ridge and coincident audio-magnetotelluric (AMT) resistive zone south of Keg Pass (Campbell and Visnyei, 1989) to be ring fracture and resurgent core intrusions, respectively.

Geological evidence for the existence of the Keg cauldron is the ash-flow origin and thickening of the Keg Tuff from 0 to 540 feet (0 to 165 m) from the north-central part of to the center of the quadrangle. Structurally, the distribution and dips of layering measured in the Keg Tuff outline a broad, low-relief dome centered on the granodiorite porphyry stock (Tgd). Because of similarities in whole-rock chemical composition, age, and spatial distribution, we consider this stock to be comagmatic with the Keg Tuff and consider it to be a resurgent intrusion that caused doming. A paired magnetic high and low, characteristic of shallow intrusions, are near the stock (figure 7; Kucks, 1991). Also, the Mt. Laird Tuff is missing over the resurgent center of our Keg cauldron.

The northern margin of the cauldron shown in figure 7 corresponds (approximately) with the northern limit of the preserved distribution of the Keg Tuff. The southwestern margin of the cauldron probably lies to the north of the southwest part of the Picture Rock Hills quadrangle (Shubat, 1999).

Thomas Caldera

Shawe (1972) first recognized the Thomas caldera and Lindsey (1982), working in the Thomas Range, provided a detailed account of the history of the caldera. Lindsey (1982) proposed that the caldera was the source of the Mt. Laird Tuff. The southern and western margins of the caldera were well defined by Lindsey (1982) and Shawe (1972), but the locations of the northern and eastern margins remained ill defined.

We place the eastern edge of the Thomas caldera along the western margin of Keg Mountain (figure 7), similar to that drawn by Shawe (1972) and Lindsey (1982), for geologic and geophysical reasons. Mapping revealed no stratigraphic or structural evidence for the margin of the Thomas caldera passing through or east of Keg Mountain. Detailed mapping has shown that, where top and bottom contacts are exposed, only thin sections of Mt. Laird Tuff are present between the Keg and Joy Tuff, and that over the resurgent center of the proposed Keg cauldron the Mt. Laird Tuff is missing. Therefore, we interpret most of the Mt. Laird Tuff at Keg Mountain to be a thin outflow facies of the formation, implying that the caldera margin must lie west of Keg Mountain. Geophysically, a likely place to draw the eastern margin of the Thomas caldera is a persistent gravity gradient along the western margin of Keg Mountain (figure 7). This gravity gradient may in part represent unconsolidated basin-fill deposits underlying the valley between the Thomas Range, and Keg Mountain and Picture Rock Hills, but may also represent intracaldera fill of the Thomas caldera and Dugway Valley cauldron.

Dugway Valley Cauldron

Lindsey (1982) identified and named the Dugway Valley cauldron (figure 7) and proposed that it was the source of the Joy Tuff. Dugway Valley is actually northwest of Keg Mountain, north of the cauldron (figure 1). Lindsey (1982) defined the location of the southwestern margin of the cauldron by the presence of vent breccias, faults, and landslide breccias. The southeastern margin was defined by Shubat (1999) using borehole data. The locations of the remaining margins of this cauldron, however, remained ill defined. In the Picture Rock Hills quadrangle, the eastern margin of the Dugway Valley cauldron is shown along the same gravity gradient used to define the Thomas caldera, and passes through the western part of the Picture Rock Hills quadrangle, concealed beneath Quaternary deposits (Shubat, 1999). The relationship between rhyolite porphyry intrusions, apparently comagmatic with the Joy Tuff, and the Dugway Valley cauldron remains enigmatic. Because exposures of rhyolite porphyry (Trp), which form north- to east-trending zones at Keg Mountain, are outside the proposed cauldron.

Picture Rock Cauldron

The existence of the Picture Rock cauldron is speculative (Shubat, 1999). It is noted in this report to make the reader aware of its possible presence (figure 7). Evidence for the existence of the cauldron consists of two geophysical observations: (1) an oval-shaped gravity low (figure 7) may outline the cauldron and (2) the cauldron is coincident with low-resistivity material at depth (Campbell and Visnyei, 1989) that could be intracauldron fill. Both of these geophysical features could be produced by unconsolidated basin fill. There is no evidence to suggest which ash-flow tuff was vented from the cauldron, but one possibility is the Dell Tuff.

Zones Marked by Rhyolite Porphyry Intrusions

The rhyolite porphyry intrusions (Trp) in the Keg Pass, Keg Mountain Ranch (Shubat and others, 1999), and Picture Rock Hills (Shubat, 1999) quadrangles fall into two northeast-trending zones, a north-south-trending zone, and, possibly, a much shorter east-west-trending zone. All the zones consist of many small dikes and plugs of rhyolite porphyry that are typically elongate north-south to northeast-southwest. No faults are mapped within these zones, so the control for the rhyolite porphyry distribution is not known.

The northern-most zone is about 3.0 miles (4.9 km) long, trends northeast, and lies entirely within the south half of the Keg Pass quadrangle. The zone cuts the northern end of the granodiorite porphyry intrusion (Tgd); and, on the west side of this intrusion, appears to cross the north-south zone and bifurcate into a short (0.8 miles [1.3 km]), east-west-trending zone of dikes and a more easterly trending southwest extension of the northernmost zone.

The north-south zone is about 2 miles (3.2 km) long, cuts the west side of the granodiorite porphyry intrusion (Tgd), and crosses both northeast-trending zones. Many of the intrusion in the north-south zone look like wide dikes in plan view (plate 1). The north-south zone might follow faults that previously developed during resurgence of the Keg cauldron.

The southernmost zone is about 7.0 miles (11.2 km) long, also trends northeast, and traverses the Picture Rock Hills, Keg Pass, and Keg Mountain Ranch quadrangles. The zone is interrupted, approximately at its midpoint, by the granodiorite porphyry intrusion (Tgd) in the south half of the Keg Pass quadrangle.

We infer that the northeast- and east-trending zones were parallel to the maximum principal horizontal stress direction (about N. 45° E. and N. 75° E.) at the time of intrusion of rhyolite porphyry (35.14 ± 0.15 Ma, table 1). This interpretation is in rough agreement with the results (N. 60° to 80° E.) obtained by Best (1988) for Oligocene dikes (32 to 34 million years old) and more westerly orientations shown by Ren and others (1989), derived from Oligocene plutons (31 to 35 million years old), in the eastern Great Basin.

High-Angle Faults

High-angle faults in the Keg Pass quadrangle have variable orientations, and amounts of demonstrable stratigraphic separation across these faults are small (less than 200 feet; 60 m). Examination of striated surfaces on some faults yielded a normal sense of slip. Air-photo lineaments have a similar variety of orientations and are presumed to be high-angle faults. The age of the high-angle faulting is apparently Eocene to Quaternary.

Well-exposed field relations and geochronology tightly constrain the onset of at least some of the high-angle faulting. One north-northeast-striking fault in the center of the Keg Pass quadrangle (section 1, T. 12 S., R. 10 W., and section 6, T. 12 S., R. 9 W.) drops the base of the Keg Tuff (Tk) 50 feet (15 m) down to the west. An elongate dacite porphyry plug (Tdp) then intruded part of the fault. Dates for the Keg Tuff and the dacite porphyry intrusions indicate that the age of this fault is between 36.77 ± 0.12 and 36.49 ± 0.15 Ma (table 1).

Two observations bracket the minimum age of faulting. Mapping in the adjacent Keg Mtn. Ranch quadrangle (Shubat and others, 1999) demonstrated that high-angle faults cut flows of the rhyolite of Keg Mountain, the youngest of which Plavidal (1987) dated at 6.7 ± 0.3 Ma. Fault scarps are not present in Quaternary units in the Keg Pass quadrangle. But fault scarps are present in latest Pleistocene Lake Bonneville deposits and some Holocene deposits in the Picture Rock Hills quadrangle (Shubat, 1999) and just east of the Keg Mtn. Ranch quadrangle (Oviatt and others, 1994).

In the Thomas Range, Lindsey (1982) determined that high-angle faults largely postdated the Spor Mountain Formation (21 million years old). He also noted that only minor block faulting occurred after eruption of the Topaz Mountain Rhyolite (6 to 8 million years old), thus bracketing the age of most of the high-angle faulting in the Thomas Range between 21 and 6 million years old. This age range may well apply to most of the high-angle normal faults mapped in the Keg Pass quadrangle.

Lineaments Marked by Topaz Mountain Rhyolite

Dike-like intrusions, isolated domes, coalesced flows and domes, and exposures of Topaz Mountain Rhyolite delineate several north-northwest-trending lineaments in the Keg Pass, Picture Rock Hills (Shubat, 1999), and Keg Mtn. Ranch (Shubat and others, 1999) quadrangles. Dike-like bodies of Topaz Mountain Rhyolite trend about north-northwest, and isolated domes are aligned in the same direction. Coalesced flows and domes form ridges and exposures of Topaz Mountain Rhyolite that also trend north-northwest (for example on the west margin of the quadrangle). No faults mapped appear to coincide with the lineaments, but one fault near Flint Spring (section 34, T. 11 S., R. 10 W.) is nearly co-linear with a Topaz Mountain Rhyolite exposure. In addition, two faults on the south margin of the quadrangle and several air-photo lineaments have this trend.

Two examples of lineaments of isolated domes are in the south-central part of the Keg Pass quadrangle. One is at least 2.0 miles (3.2 km) long, trends N. 34° W., and extends from the east-central edge of section 11, T. 12 S., R. 10 W. north-northwest into the SE¼ section 21, T. 11 S., R. 10 W. Another lineament is 1.5 miles (2.4 km) long and trends N. 35° W. The southeastern end of this lineament is in the southwestern corner of section 13, T. 12 S., R. 10 W.

We interpret the lineaments as being parallel to the maximum principal horizontal stress direction (N. 35° W.) at the time of intrusion and eruption of the Topaz Mountain Rhyolite, between 8 and 6 million years old. This interpretation is in rough agreement with the results (N. 20° to 25° W.) obtained by Zoback and others (1981) in the northern Great Basin for the Miocene (6 to 20 million years ago).

ECONOMIC RESOURCES

Metallic Minerals

Mineral exploration at Keg Mountain since 1978 was spurred by Morris' (1978) report of unprospected, lead- and zinc-enriched, pyritized rock (common corner sections 29, 30, 31 and 32, T. 11 S., R. 9 W.), and resulted in discoveries of lead-, silver-, copper- and gold-bearing mineralization at other sites (figure 3; Shubat, 1987). Occurrences fall into three categories, volcanic-hosted gold; sediment-hosted polymetallic (lead-zinc-silver dominated) vein and replacement at dome hill; carbonate-hosted jasperoid prospects at lead hill and gold basin, and pods of galena replacing limestone at lead hill; and copper-rich pods at copper hill. Shubat (1987) reported additional information on these occurrences. Prospects shown on the published U.S. Geological Survey topographic map (base map for plate 1) are not prospects, but were dug as stock watering holes. Zimbelman and others (1991) provided some analytical data for metals in rock samples from Keg Mountain.

Volcanic-hosted Gold Occurrences

The best explored volcanic-hosted gold occurrence at Keg Mountain lies about 3,300 feet (1 km) southwest of the copper hill prospect (figure 3; NW¼NW¼ section 36, T. 11 S., R. 10 W.) near a dacite porphyry plug (Tdp). Industry geologists discovered the prospect in 1987 and explored it with 14 drill holes in 1988 and 1989. Gold values occur along a high-angle, northwest-striking, southwest-dipping normal fault that juxtaposes the Mt. Laird Tuff (hanging wall) against the lithic-crystal, ash-flow tuff member of the Dead Ox Tuff. Alteration consists of intense argillization and pyritization of the Dead Ox Tuff within a few meters of the fault. The highest values obtained to date average 1.02 ppm Au over a 20-foot (6 m) drill-hole interval.

Other areas with anomalous gold values are shown in figure 3; they occur near pebble dikes (Tpd) that cut the Mt. Laird Tuff and a possible Mt. Laird vent (in the Keg Mtn. Ranch quadrangle), and near air-photo lineaments (NE¼ section 35, T. 11 S., R. 10 W.).

Dome Hill Prospect

The Prospect Mountain Quartzite hosts the polymetallic vein and replacement occurrence at dome hill (figure 3). Structurally, the hill constitutes the southwestern half of a dome that is cut by several high-angle faults, the most prominent of which consists of a silicified rib along the long, northwest-trending axis of the hill. Mineralized rock at Dome Hill consists of highly oxidized stockwork and replacement occurrences. Quartzite and phyllite are present at the surface. Observed primary sulfide minerals are pyrite, galena, tetrahedrite-tennantite, and rare chalcopyrite. Analyses of mineralized samples show high concentrations of silver (as much as 27 oz/ton in bulk samples) and bismuth (as much as 3.7 percent) and locally high values of gold (6.5 ppm), base metals (lead and copper), arsenic, and antimony.

Faults and fractures control the exposed distribution of mineralized rock at Dome Hill and geochemical sampling showed that highly anomalous samples spatially coincide with the dominant northwest-trending fault along the crest of the hill. Mineralized rock apparently extends over 3,000 feet (900 m) to the northwest from the top of the hill to an area of concealed mineralized rock discovered by drilling (figure 3). Drill holes in this area (NE¼NE¼ section 33, T. 11 S., R. 10 W.) tested a northeast-trending self-potential responder near northeast-striking air-photo lineaments. Drill core showed the presence of quartz veinlets in carbonate host rock, both containing pyrite, galena, and sphalerite, and several intercepts of disseminated sulfides in silicified breccia zones. One stockwork zone contained 0.70 oz/ton silver, 0.55 percent lead, and 0.54 percent zinc over a 10-foot (3 m) interval.

Lead Hill Prospect

Two types of mineralized rock occur at Lead Hill: (1) carbonate-hosted gold-, silver-, lead-, zinc-, and molybdenum-bearing jasperoid, and (2) small, massive pods of galena replacing limestone. Both types are in undifferentiated Cambrian carbonate rock (Cl).

Mineralized jasperoid bodies (center S½NW¼ section 31, T. 11 S., R. 9 W.) occur along high-angle faults and fracture zones, forming resistant, dark-brown masses about 5 to 30 feet (1.5 to 9 m) in length and 2 to 10 feet (0.6 to 3 m) in width. Ore minerals in jasperoid consist of sparse, fine-grained pyrite and galena. Gangue mineralogy consists almost entirely of microcrystalline, chalcedonic silica with a ubiquitous iron-oxide stain and trace amounts of sericite. Geochemical analyses of jasperoid samples show an enrichment in lead, silver, molybdenum, gold and zinc. The highest values obtained from jasperoid samples are 1.89 percent lead, 7.88 oz/ton silver, 691 ppm molybdenum, 0.59 ppm gold, and 2,500 ppm zinc.

The second type of mineralized rock consists of small (1 foot [30 cm] diameter) pods of nearly massive galena replacing limestone adjacent to a propylitized granodiorite dike exposed in a prospect trench at the north end of Lead Hill (center N½NW¼ section 31, T. 11 S., R. 9 W.). Analyses of the galena-rich pods showed low silver values (0.66 oz/ton) and trace amounts of zinc in addition to lead.

Copper Hill Prospect

Mineralized rock at the prospect consists of small, oxidized, nearly massive pods of chalcopyrite along fractures in Prospect Mountain quartzite near a thrust fault and a northeast-striking high-angle fault (SW¼SE¼ section 25, T. 11 S., R. 10 W.). These pods are less than 6 inches (15 cm) in length and 1 inch (2 cm) in width. Pods have been oxidized to hematite, limonite, malachite and sparse covellite. Host fractures strike N. 50° W. and dip 80° SW. Geochemical analyses show the mineralized rock contains as much as 11 percent copper and iron enrichment, but no other metal enrichments were present.

Industrial Minerals and Rocks

Sand and Gravel

Abundant sand and gravel are present in the quadrangle in lacustrine gravel (Qlg); these sand and gravel deposits are moderately well sorted and were deposited near the shore of Lake Bonneville in beaches and bars. Another possible source of sand and gravel is lacustrine sand with silt and pebbles (Qls). These shorezone deposits may be up to 30 feet (10 m) thick between the Bonneville and Provo shorelines on the north flank of Keg Mountain. Well-sorted, fine- to medium-grained sand is present in eolian dunes (Qes). Sand and gravel are also abundant in alluvial and alluvial-fan deposits of all ages, although they are less well sorted, more angular, and contain more fines than lacustrine deposits.

Cement Rock

Several Cambrian rock units in the quadrangle might have potential as cement raw materials. Silty limestone in the Howell Limestone (€h) may have desirable concentrations of calcium carbonate, alumina, and iron, while the Pioche Formation (€pt, €pl) could be a source of alumina and silica for cement.

High-Calcium Limestone

Some limestone units in the quadrangle (€h, €l) might have potential as high-calcium limestone. Continental Lime, Incorporated has a plant in the Cricket Mountains, about 50 miles (90 km) to the south, that produces high-calcium lime from limestone in the Cambrian Dome Formation (Tripp, 1991). The Dome Formation may be present in the undifferentiated Cambrian carbonate rock map unit (€l).

Zeolite Minerals

Significant zeolite mineralization (clinoptilolite) exists in the stratified tuff member of the Topaz Mountain Rhyolite (Ttmt) on Keg Mountain (Lindsey, 1975). Clinoptilolite makes up between 60 and 90 percent of the rock, and is the only zeolite mineral identified in the area (Lindsey and others, 1974). Mayes and Tripp (1991) summarized the available information on the mineralization. Lindsey (1975) showed that alteration of the tuff produced feldspathic as well as zeolitic minerals assemblages. The feldspathic assemblage contains potassium feldspar as the dominant mineral. Lindsey (1975) concluded that the alteration was caused by percolating ground water that leached alkalis from glass in the tuff, forming, progressively, the zeolitic and feldspathic assemblages.

Crushed Stone and Dimension Stone

The Prospect Mountain Quartzite (€pm), Joy Tuff (Tj), and rhyolite flow, dome and intrusion member of the Topaz Mountain Rhyolite (Ttm) could be used for crushed stone. The Joy Tuff could be used for dimension stone where massive and very densely welded. The rock contains abundant rock fragments and crystals in a reddish-brown, locally laminated matrix of devitrified glass. Sufficiently large pieces could be quarried and cut for tile or facing stone. Crushed devitrified rhyolite could be used for road base material, bituminous aggregate, or possibly cement aggregate.

Lapidary Materials

Staub (1975) noted several varieties of lapidary materials in Topaz Mountain Rhyolite (her Keg Mountains Rhyolite). The best known are the topaz crystals, for which Topaz Mountain got its name. In the Picture Rock Hills, these crystals are usually less than 0.6 inches (15 mm) long. Thunder eggs are reported in the stratified tuff (Ttmt), and obsidian also is reported (Staub, 1975), presumably in vitrophyres in the flow, dome and intrusion member (Ttm). None of the vitrophyres observed were perlitic.

WATER RESOURCES

No perennial streams flow in the quadrangle. Three springs are present. Keg Spring (NW¼NW¼section 8, T. 12 S., R. 9 W.) apparently emerges from alluvium and colluvium (Qac), while Flint Spring (SW¼SE¼ section 34, T. 11 S., R. 10 W.) is apparently on a fault in Topaz Mountain Rhyolite flows (Ttm). Improvements at the springs, and discharge from both springs has been diverted to storage tanks for livestock (Stephens and Sumsion, 1978), obscure their origin. The other unnamed spring apparently emerges from the Topaz Mountain Rhyolite stratified tuff (Ttmt) on the south margin of the quadrangle (NW¼section 23, T. 12 S., R. 10 W.). Its flow has also been captured and diverted. Stephens and Sumsion (1978) also list this spring. Gates and Kruer (1981) reported that the calculated total dissolved solids in water from the Keg and Flint Springs is 1,810 and 1,910 milligrams/liter (~ppm), respectively. Waddell (1967) reported 2,130 and 2,300 parts/million (~mg/l) evaporated total dissolved solids, respectively, and other analytical results for the waters.

No water wells are known in the quadrangle. The nearest well is 1.5 miles (2.4 km) west-northwest of the northwest corner of the quadrangle, in section 12, T. 11 S., R. 11 W.; the depth to water in this well is about 270 feet (82 m) (Stephens and Sumsion, 1978; Bedinger and others, 1984). Unconsolidated deposits in the northwest part of the quadrangle may likewise contain ground water, but the potential for production from wells is not known. Gates and Kruer (1981) indicated that any ground water in this unconsolidated aquifer is probably moderately saline (3,000 to 10,000 milligrams/liter [~ppm] total dissolved solids; see also Waddell, 1967).

GEOLOGIC HAZARDS

In general, few significant geologic hazards are present in the quadrangle. Virtually no construction or development has taken place in the quadrangle, and no observations or historical records of hazard events are available.

No earthquakes larger than magnitude 4 have occurred in historical time within 30 miles (50 km) of the quadrangle (Goter, 1990). No active or potentially active (Quaternary) faults were mapped in the quadrangle. The nearest faults with evidence for displacement in post-Bonneville time are just east of the Keg Mtn. Ranch quadrangle on the east side of the Old River Bed (Oviatt and others, 1994) and between the Picture Rock Hills and Crater Bench (Shubat, 1999; Oviatt and others, 1994). The principal earthquake hazard would be from strong ground shaking in a moderate to large earthquake. The quadrangle is at the boundary between seismic zones 2B and 3 (International Conference of Building Officials, 1991), an area of moderate earthquake hazard.

Slopes in the area are generally stable; no landslides were mapped in the quadrangle. The principal slope-failure hazard is from rock falls (figure 10) below steep, rocky slopes.

__Figure 10.__ Rock-fall clasts of Topaz Mountain Rhyolite that have rolled from the hillside in the background onto unconsolidated deposits at the base of the slope (SE1/4, section 29, T. 11 S., R. 10 W.).

Flash flooding is possible along any of the dry washes (Qal) and on active alluvial fans and sheet-wash slopes (Qaf_1, Qac). Cloudburst-generated debris flows are possible in mountain channels (units Qal, Qac) and at the apices of modern alluvial fans (Qaf_1).

Soil and ground-water conditions should present few problems for building foundations. Soils are generally granular sand and gravel with little clay. It is possible that collapsible soils subject to hydrocompaction may occur on modern alluvial fans (Qaf_1) at mountain fronts, and that expansive, soluble, and erodible materials are present in the fine-grained deep-lake sediments (Qlm) in the northwest corner of the quadrangle. Shallow ground water is probably not present anywhere in the quadrangle (see Stephens and Sumsion, 1978).

Some volcanic rocks at Keg Mountain and the Picture Rock Hills are uranium-bearing (Zielinski and others, 1980; Shubat, 1999) and may produce radon gas (Solomon, 1992; Black, 1993). The generally coarse-grained, dry soils are conducive to the movement of radon gas through soil and into structures (Solomon, 1992; Black, 1993).

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APPENDICES

Not all rock types listed in appendix A and B, and shown in figures 3 and 4, are exposed in this quadrangle. Units Tap (andesite porphyry), Tdo (Dead Ox Tuff), Tdp (dacite porphyry), and Tqm (quartz monzonite) are only exposed in the Keg Pass quadrangle (this report). Unit Td (Dell Tuff) is not exposed in the Picture Rock Hills quadrangle but might be present in subsurface (Shubat, 1999). Unit Tkm (rhyolite of Keg Mountain) is only exposed in the Keg Mtn. Ranch quadrangle.

Sample number letter prefixes show in which quadrangle the sample was taken. NKM and KP were used for samples from the Keg Pass quadrangle. PRH and KMR were used for samples from the Picture Rock Hills and Keg Mtn. Ranch quadrangles, respectively.

APPENDIX A

Table 1.
Modal analyses of igneous rocks in the Keg Mountain area. Map symbols same as on plates 1 and 2. All values in percent except number of counts, sphene, and zircon. Symbols for sphene and zircon are n = absent and y = present.

sample number	map symbols	no. of counts	matrix	plagio-clase	quartz	alkali feldspar	biotite	horn-blende	clino-pyroxene	opaque minerals	sphene	zircon	lithic & pumice clasts
NKM-22-1	Ta	735	44.08	32.11	7.89	0.00	5.58	3.67	0.14	0.54	n	n	5.99
NKM-17-6	Tap	793	49.81	33.17	2.52	0.00	5.93	5.80	0.38	2.40	n	y	0.00
KP-7-9	Tap	735	45.99	35.24	3.81	0.00	6.39	5.58	1.50	1.50	n	y	0.00
KP-9-8	Tap	639	40.22	33.33	7.98	0.00	8.76	4.85	2.50	2.35	n	y	0.00
NKM-1-15	Tdo	762	70.73	5.64	3.28	0.13	0.79	0.00	0.00	0.13	n	y	19.29
NKM-1-9	Tdo	835	63.35	5.99	4.19	0.48	0.60	0.00	0.00	0.12	n	y	25.27
NKM-15-8	Tdo	756	67.33	6.22	2.78	0.26	0.93	0.00	0.00	0.40	n	y	22.09
NKM-6-6	Tdo	829	65.26	8.69	4.46	0.48	0.72	0.00	0.00	0.72	n	y	19.66
NKM-9-6	Tdo	827	67.11	6.77	4.72	0.48	0.00	0.00	0.00	0.60	n	y	20.31
KMR-4-1	Tk	789	43.73	31.05	9.25	0.25	9.13	3.42	1.77	1.39	n	y	0.00
PRH-13-1	Tk	434	39.40	35.48	9.68	0.23	8.76	3.46	0.69	1.61	n	y	0.69
KP-16-4	Tk	451	45.68	34.37	6.21	0.22	6.21	4.66	1.11	1.55	n	y	0.00
KP-2-2	Tk	780	44.10	31.67	7.44	0.00	10.38	4.36	0.90	1.15	n	y	0.00
KP-8-2	Tk	502	63.94	18.33	5.18	1.00	8.57	1.79	0.20	1.00	n	y	0.00
NKM-16-9	Tk	827	63.72	16.20	4.59	0.24	7.98	3.63	0.97	1.93	n	y	0.73
NKM-2-4	Tk	826	47.22	25.67	7.38	0.36	8.60	5.33	1.69	1.45	y	y	2.30
NKM-2-5	Tk	887	56.93	22.21	6.09	0.00	5.64	5.52	1.13	0.90	n	y	1.58
PRH-2-1	Tk	709	42.74	26.38	9.03	0.00	7.05	1.83	0.85	1.55	n	y	10.58
KP-2-1	Tgd	754	0.00	32.36	30.24	17.11	9.95	8.89	0.00	1.46	n	y	0.00
KP-2-4	Tgd	730	0.00	35.89	28.90	17.81	7.95	6.58	1.10	1.78	n	y	0.00
NKM-18-3	Tgd	792	0.00	38.89	31.57	17.93	6.31	4.17	0.13	0.88	n	y	0.00
KMR-1-4	Tml	668	60.33	26.80	1.50	0.00	5.09	2.84	2.25	1.20	y	y	0.00
KMR-1-5	Tml	774	65.12	22.22	1.94	0.00	4.52	2.20	0.90	2.97	y	n	0.00
KMR-1-6	Tml	821	62.24	20.46	1.95	0.00	6.82	6.58	0.85	0.85	y	n	0.00
KMR-3-21	Tml	717	66.81	18.55	2.23	0.00	4.32	6.42	0.70	0.98	y	n	0.00
KMR-3-9	Tml	790	65.82	20.63	0.76	0.00	4.56	5.32	1.39	1.52	n	n	0.00
KMR-4-4	Tml	749	64.09	20.96	4.94	0.00	4.54	4.14	0.00	1.34	n	y	0.00
KMR-4-8	Tml	835	68.50	17.96	2.75	0.00	3.11	6.59	0.36	0.72	y	y	0.00
KMR-5-1	Tml	707	60.11	25.32	3.95	0.00	7.36	2.26	0.14	0.85	y	y	0.00
KMR-5-13	Tml	517	55.32	29.59	1.55	0.00	6.58	4.26	0.77	1.93	y	y	0.00
KMR-5-2	Tml	799	58.20	24.16	2.63	0.00	6.26	5.63	1.88	1.13	y	y	0.00
KP-12-3	Tml	528	63.07	25.00	1.33	0.00	3.22	4.92	1.70	0.76	y	y	0.00
KP-6-1	Tml	728	56.87	31.59	1.37	0.00	4.40	3.71	1.10	0.96	y	y	0.00
KP-8-7	Tml	730	58.08	25.48	2.19	0.00	4.52	6.99	1.23	1.37	y	y	0.00
NKM-18-13	Tml	694	56.34	27.52	3.17	0.00	6.05	4.76	0.00	2.02	y	y	0.00
NKM-18-15	Tml	808	60.15	24.13	2.60	0.00	5.32	6.81	0.00	0.87	y	y	0.00
NKM-21-1	Tml	814	59.71	22.48	2.83	0.00	4.18	8.85	0.00	1.84	y	y	0.00
NKM-21-12	Tml	725	63.17	22.07	2.07	0.00	2.90	7.72	0.69	1.38	y	y	0.00
NKM-21-14	Tml	791	74.21	14.66	0.51	0.00	2.78	3.67	2.91	1.26	y	y	0.00
NKM-21-5	Tml	808	59.90	22.03	1.86	0.00	4.58	9.78	0.12	1.73	y	y	0.00
NKM-21-8	Tml	767	69.36	19.43	0.13	0.00	2.48	2.61	4.17	1.69	n	y	0.00

***Table 1** (continued)*

sample number	map symbols	no. of counts	matrix	plagio-clase	quartz	alkali feldspar	biotite	horn-blende	clino-pyroxene	opaque minerals	sphene	zircon	lithic & pumice clasts
NKM-22-4	Tml	772	63.21	22.15	1.30	0.00	7.12	4.79	0.13	1.30	y	y	0.00
NKM-22-5	Tml	754	67.51	16.58	3.58	0.00	5.70	4.51	1.59	0.53	y	y	0.00
NKM-22-6	Tml	746	54.83	28.28	1.88	0.00	5.36	7.51	0.40	1.74	y	y	0.00
NKM-22-7	Tml	819	58.00	22.59	4.15	0.00	5.37	7.81	0.37	1.47	y	y	0.00
NKM-22-8	Tml	794	52.52	31.61	2.14	0.00	6.42	5.67	0.13	1.39	y	y	0.00
KP-8-8	Tdp	793	58.01	24.34	3.66	0.00	5.55	6.81	0.00	1.64	y	y	0.00
NKM-10-2	Tdp	790	68.73	15.06	1.77	0.00	1.77	3.80	7.22	1.65	n	n	0.00
NKM-21-9	Tdp	790	56.84	30.89	2.53	0.00	3.42	5.06	0.25	0.89	n	y	0.00
NKM-7-4	Tdp	784	59.69	24.11	2.55	0.00	5.36	5.99	0.00	2.30	y	y	0.00
KP-12-5	Tqm	366	0.00	30.05	33.06	29.51	4.92	1.91	0.00	0.55	n	y	0.00
KMR-1-2	Tj	796	41.21	13.32	17.46	16.83	2.39	0.00	0.00	0.13	y	n	8.29
KP-13-2	Tj	416	43.27	18.75	18.27	16.35	2.88	0.00	0.00	0.24	y	y	0.00
PRH-1-1	Tj	691	46.74	7.81	17.66	12.01	1.59	0.00	0.00	0.43	y	n	13.75
PRH-2-3	Tj	392	46.94	14.80	17.60	17.60	1.53	0.00	0.00	0.51	y	n	0.77
KMR-3-8	Trp	418	62.20	11.48	10.29	14.35	1.44	0.00	0.00	0.24	n	n	0.00
KMR-4-6	Trp	732	43.44	15.98	16.39	20.63	2.73	0.55	0.00	0.27	n	y	0.00
KMR-5-8	Trp	541	49.72	17.38	14.42	15.71	2.22	0.37	0.00	0.18	n	y	0.00
KP-15-2	Trp	429	71.10	14.45	2.33	9.79	2.33	0.00	0.00	0.00	y	y	0.00
KP-2-3	Trp	805	46.58	20.12	16.77	13.79	2.11	0.00	0.00	0.62	n	y	0.00
KP-3-3	Trp	707	51.06	14.00	16.41	16.83	1.56	0.00	0.00	0.14	n	y	0.00
KP-3-4	Trp	355	58.03	12.39	10.99	15.21	2.82	0.00	0.00	0.56	n	n	0.00
KP-3-5	Trp	457	51.42	16.19	14.22	15.75	2.41	0.00	0.00	0.00	n	n	0.00
KP-8-1	Trp	433	55.66	14.55	13.86	12.47	3.23	0.00	0.00	0.23	y	y	0.00
KMR-3-10	Td	397	31.49	11.08	16.37	18.89	3.02	0.00	0.00	0.25	n	y	18.89
KMR-5-11	Td	490	46.53	9.18	21.43	19.80	2.45	0.00	0.00	0.41	y	y	0.00
KMR-5-9	Td	467	46.47	8.99	20.13	21.41	1.71	0.43	0.00	0.64	y	y	0.00
KP-6-2	Td	386	45.64	12.44	16.84	21.24	3.11	0.26	0.00	0.26	y	y	0.26
NKM-2-2	Td	781	44.94	9.99	26.12	16.26	2.18	0.00	0.00	0.51	y	y	0.00
NKM-1-13	Ttm	652	90.64	0.31	6.44	2.30	0.00	0.00	0.00	0.31	n	n	0.00
KMR-13-3	Ttm	479	54.91	17.33	17.33	7.72	2.51	0.00	0.00	0.21	y	y	0.00

Table 2.
Selected modal analyses of rhyolite of Keg Mountain from Plavidal (1987). Map symbols same as on plates 1 and 2. All values in percent.

symbol number	map symbol	matrix	plagio-clase	quartz	alkali feldspar	biotite	horn-blende	clino-pyroxene	opaque minerals
19V	Tkm	81.4	2.3	8.7	6.5	0.6	0.2	0.1	0.1
48V	Tkm	84.6	0.8	7.1	5.1	1.0	0.4	—	0.9
65V	Tkm	80.7	5.0	7.5	4.2	1.0	0.6	0.6	0.4
66V	Tkm	84.5	2.8	3.9	5.2	0.7	0.9	0.7	1.3
74V	Tkm	59.0	4.6	13.2	18.2	0.9	2.5	0.2	1.3
76V	Tkm	86.9	2.7	4.9	3.1	1.2	0.7	0.1	0.4
84V	Tkm	80.4	0.3	13.5	5.0	0.7	—	—	—
HKV	Tkm	79.4	1.1	15.2	3.1	0.5	0.2	—	0.3

APPENDIX B

Table 1.
Whole rock geochemical data for igneous rocks in the Keg Mountain area. Map symbols same as on plates 1 and 2. $FeTO_3$ refers to total iron reported as Fe_2O_3. Analyses provided by the U.S. Geological Survey; XRF chemical methods described by Baedecker (1987). All values in percent, recalculated to 100 percent after loss on ignition (LOI) subtracted.

sample number	map symbol	SiO_2	Al_2O_3	$FeTO_3$	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI
KP-7-7	Ta	64.82	16.15	5.67	2.15	3.36	3.27	3.49	0.74	0.26	0.09	1.65
KP-15-1	Ta	61.01	16.53	6.47	2.79	4.23	4.24	3.25	1.04	0.39	0.05	3.96
KP-17-1	Ta	65.22	14.94	6.50	1.88	3.64	2.97	3.66	0.84	0.30	0.06	2.24
KP-7-9	Tap	63.16	16.22	5.80	2.21	5.00	3.32	3.21	0.74	0.26	0.08	1.57
KP-9-8	Tap	64.07	15.79	5.67	2.26	4.38	3.44	3.36	0.72	0.24	0.08	1.89
KP-9-4	Tk	67.77	14.77	4.31	1.66	3.19	3.19	4.23	0.57	0.24	0.07	2.31
KP-7-10	Tk	68.77	14.25	4.49	1.58	3.08	2.37	4.56	0.61	0.23	0.05	3.27
KMR-4-3	Tk	67.48	14.56	5.03	1.87	3.40	2.90	3.80	0.66	0.25	0.05	1.75
KP-1-1	Tk	63.99	15.95	5.74	2.10	4.77	3.05	3.34	0.74	0.25	0.07	3.14
KP-11-2	Tk	64.28	15.71	5.61	1.87	5.04	2.95	3.47	0.71	0.26	0.10	2.64
KP-16-3	Tk	63.21	16.01	5.84	1.71	5.89	3.15	3.10	0.74	0.25	0.10	2.59
KP-16-4	Tk	63.21	15.98	5.73	2.31	4.98	3.38	3.37	0.72	0.25	0.08	1.67
KP-2-2	Tk	64.08	15.76	5.63	1.81	5.32	3.06	3.29	0.72	0.25	0.08	3.14
KP-6-5	Tk	63.92	15.85	5.68	2.52	5.11	3.07	2.80	0.73	0.26	0.08	3.00
KP-8-2	Tk	67.19	15.10	4.74	1.82	3.07	2.89	4.26	0.64	0.25	0.05	2.08
KP-2-1	Tgd	64.37	15.68	5.38	2.33	4.55	3.38	3.27	0.71	0.25	0.07	2.65
KMR-1-4	Tml	63.80	15.98	5.90	2.10	4.54	3.11	3.41	0.79	0.28	0.08	3.90
KMR-3-13	Tml	65.15	14.92	5.84	1.42	5.10	2.24	4.21	0.79	0.25	0.08	4.05
KMR-3-21	Tml	71.05	12.92	4.71	1.34	3.75	2.56	2.79	0.58	0.23	0.07	1.90
KMR-3-9	Tml	63.43	15.05	6.56	2.54	4.93	3.11	3.24	0.78	0.28	0.06	3.11
KMR-4-7	Tml	64.38	15.49	5.72	2.55	3.96	3.04	3.75	0.75	0.27	0.09	3.71
KMR-4-8	Tml	63.39	15.67	6.17	2.92	4.33	2.88	3.44	0.82	0.29	0.09	2.61
KMR-5-13	Tml	62.30	15.65	6.72	3.31	3.44	3.72	3.62	0.84	0.29	0.11	2.14
KMR-5-17	Tml	66.14	14.45	5.19	1.94	4.20	2.43	4.64	0.68	0.25	0.06	1.45
KMR-5-18	Tml	64.09	15.66	5.77	2.42	5.46	2.29	3.16	0.78	0.27	0.09	3.84
KMR-5-3	Tml	64.51	15.04	5.88	2.02	4.16	2.67	4.62	0.76	0.26	0.07	1.06
KP-12-1	Tml	66.97	15.44	4.86	1.55	2.73	3.22	4.34	0.62	0.21	0.05	1.71
KP-12-3	Tml	63.03	15.40	6.47	2.65	4.85	3.22	3.20	0.81	0.28	0.10	2.29
KP-14-4	Tml	61.94	16.59	6.87	2.01	3.85	3.67	3.68	0.96	0.39	0.05	1.89
KP-5-22	Tml	71.87	12.11	4.20	1.46	2.52	1.88	5.22	0.46	0.22	0.04	1.16
KP-6-1	Tml	63.18	15.95	6.02	2.23	5.48	2.76	3.16	0.87	0.28	0.08	2.97
KP-8-7	Tml	65.07	15.52	5.60	2.07	4.21	2.99	3.43	0.75	0.27	0.08	2.15
KP-8-8	Tdp	64.31	15.50	5.45	2.29	4.27	3.48	3.64	0.73	0.26	0.07	3.25
KP-9-1	Tdp	65.17	15.57	5.23	2.14	3.58	3.60	3.70	0.68	0.25	0.08	2.99
KP-9-2	Tdp	65.53	15.41	5.20	2.07	4.19	3.00	3.62	0.65	0.24	0.09	4.15
KP-12-5	Tqm	67.88	15.28	4.20	1.55	2.55	2.99	4.71	0.58	0.22	0.04	3.33
KMR-1-2	Tj	73.77	13.85	1.74	0.51	1.78	3.33	4.63	0.24	0.08	0.06	1.55
PRH-2-3	Tj	73.92	13.26	2.12	0.64	1.80	3.49	4.32	0.27	0.11	0.06	0.55
PRH-1-1	Tj	74.77	13.59	1.82	0.47	1.38	3.12	4.42	0.27	0.11	0.04	1.26
KP-13-2	Tj	63.99	15.56	6.17	1.29	4.94	2.89	3.73	1.00	0.38	0.05	3.16
KMR-3-8	Trp	74.83	12.56	1.49	0.47	2.61	3.31	4.37	0.20	0.08	0.06	2.04
KMR-4-6	Trp	73.73	13.73	1.46	0.49	2.82	2.88	4.48	0.23	0.10	0.08	2.44
KP-15-2	Trp	74.01	14.43	1.38	0.60	1.32	3.26	4.68	0.20	0.06	0.06	1.93
KP-16-2	Trp	72.71	15.08	1.84	0.84	0.63	3.53	4.96	0.28	0.09	0.03	2.86
KP-3-1A	Trp	76.16	13.47	1.66	0.63	1.09	1.95	4.66	0.22	0.09	0.07	2.80
KP-3-1B	Trp	78.42	12.10	0.46	0.16	2.53	1.01	5.20	0.05	0.03	0.05	5.07
KP-3-1C	Trp	77.03	12.72	0.82	0.24	1.80	2.15	5.08	0.10	0.03	0.03	3.25
KP-3-4	Trp	74.93	13.81	1.56	0.59	1.43	2.63	4.71	0.21	0.08	0.05	2.19
KP-3-5	Trp	74.44	13.90	1.63	0.63	1.41	2.59	5.07	0.22	0.09	0.03	1.87
KP-8-1	Trp	75.31	13.75	1.60	0.61	1.16	2.31	4.91	0.22	0.09	0.05	2.05
KMR-3-11	Td	75.33	13.27	1.78	0.52	1.49	2.77	4.48	0.23	0.09	0.04	1.34
KMR-5-10	Td	74.15	13.96	1.50	0.52	1.94	2.87	4.74	0.21	0.08	0.03	3.21

Table 1 (continued)

sample number	map symbol	SiO_2	Al_2O_3	$FeTO_3$	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI
KMR-5-11	Td	75.04	13.27	1.65	0.55	1.53	2.77	4.85	0.22	0.08	0.03	1.43
KMR-5-9	Td	75.05	13.38	1.65	0.57	1.54	2.88	4.59	0.22	0.08	0.03	1.20
KP-6-2	Td	75.11	13.23	1.55	0.55	1.53	3.05	4.63	0.23	0.09	0.02	0.94
KP-11-3	Ttm	76.35	12.30	0.85	0.25	1.28	3.43	5.31	0.14	0.03	0.05	1.11
KMR-13-3	Ttm	76.21	12.53	1.22	0.41	1.14	2.29	5.83	0.29	0.06	0.01	2.15

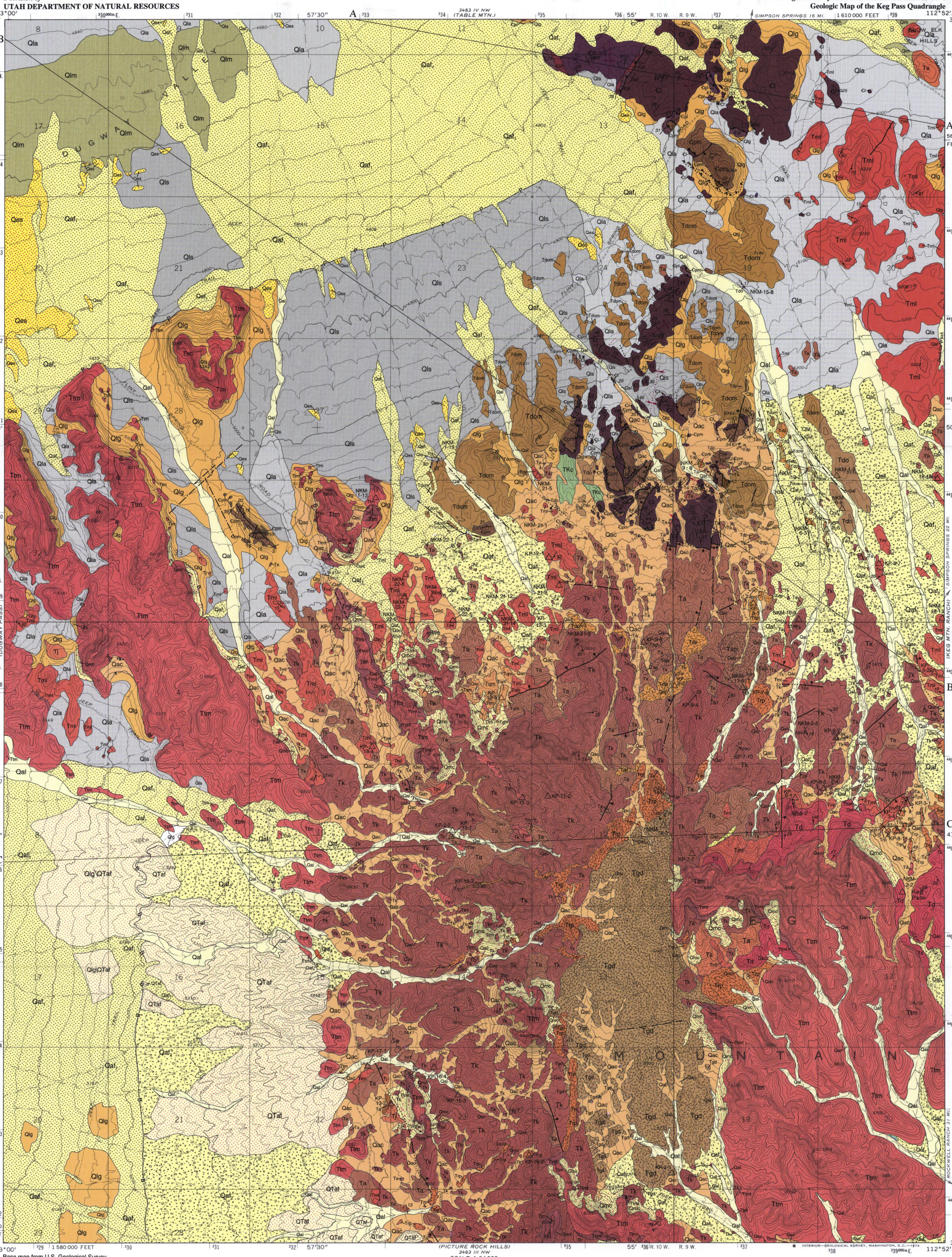
Table 2.

Selected whole-rock geochemical data for rhyolite of Keg Mountain from Plavidal (1987). Map symbols same as on plates 1 and 2. All values in percent.

sample number	map symbol	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	H_2O+	H_2O-	TOTAL
19V	Tkm	71.30	13.10	1.12	0.74	0.37	1.27	2.87	5.52	0.22	0.07	0.06	1.68	0.20	98.5
48V	Tkm	74.90	11.60	0.73	0.48	0.32	0.78	2.79	5.21	0.14	0.03	0.05	1.68	0.15	98.9
65V	Tkm	71.60	12.90	1.07	0.71	0.41	1.07	2.89	5.61	0.21	0.05	0.05	1.68	0.16	98.4
66V	Tkm	72.60	13.00	0.95	0.63	0.33	1.00	3.00	5.53	0.19	0.05	0.05	1.68	0.26	99.2
74V	Tkm	71.70	13.10	0.97	0.64	0.57	1.49	2.94	5.52	0.20	0.06	0.05	1.47	0.13	98.8
76V	Tkm	73.90	12.30	0.98	0.65	0.28	0.88	3.01	5.43	0.19	0.03	0.06	2.16	0.16	100.0
84V	Tkm	74.44	11.90	0.66	0.44	0.23	0.79	2.82	5.41	0.12	0.02	0.05	1.68	0.20	98.8
HKV	Tkm	74.10	12.00	0.70	0.46	0.17	0.71	2.86	5.27	0.12	0.01	0.06	1.80	0.23	98.5

UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES

Plate 1
Utah Geological Survey Miscellaneous Publication MP-99-4
Geologic Map of the Keg Pass Quadrangle



Base map from U.S. Geological Survey
Keg Pass 7.5' Quadrangle, 1971

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

14.1°
251 MILS

1999 MAGNETIC DECLINATION
AT CENTER OF SHEET

UTAH
QUADRANGLE LOCATION

The Miscellaneous Publication Maps provide an outlet for authors who are not Utah Geological Survey staff. Not all aspects of this publication have been reviewed by the UGS.

GEOLOGIC MAP OF THE KEG PASS QUADRANGLE, JUAB COUNTY, UTAH

by

Michael A. Shubat and Gary E. Christenson

1999

DESCRIPTION OF GEOLOGIC UNITS

(Starred [*] names are newly proposed units)

Qal Stream alluvium (Holocene) - Unconsolidated, poorly sorted clay, silt, sand, pebbles, cobbles and boulders in modern stream channels, floodplains, and terraces 3 to 6 feet (1 to 2 m) above modern channels; generally less than 10 feet (<3 m) thick.

Qes Eolian sand (Holocene) - Unconsolidated, well-sorted sand, chiefly in stabilized dunes that are now being eroded; located below the Bonneville shoreline and derived from lacustrine deposits; generally less than 10 feet (<3 m) thick.

Qaf_1 Younger alluvial-fan deposits (Holocene and latest Pleistocene) - Unconsolidated, poorly sorted clay, silt, sand, and gravel found principally below the Bonneville shoreline; generally less than 10 feet (<3 m) thick.

Qla Undifferentiated lacustrine and alluvial deposits (Holocene and latest Pleistocene) - Unconsolidated sand, pebbles, and cobbles consisting of lacustrine deposits partially reworked by post-lacustrine streams and slope wash, pre-lacustrine alluvial-fan deposits partially reworked by Lake Bonneville, and alluvial and lacustrine deposits that cannot be differentiated at the map scale; rarely more than 10 feet (>3 m) thick.

Qac Alluvium and colluvium (Holocene and Pleistocene) - Unconsolidated, poorly sorted clay, silt, sand, pebbles, cobbles, and boulders in first-order drainages, alluviated slopes below colluvium, and poorly developed alluvial fans; generally less than 10 feet (<3 m) thick.

Qmc Colluvium (Holocene and Pleistocene) - Unconsolidated colluvium, and cobble- to boulder-sized talus on steep mountain slopes below rock outcrops; up to 30 feet (9 m), but generally less than 10 feet (<3 m) thick.

Qlg Lacustrine gravel (latest Pleistocene) - Unconsolidated, sand, and pebble-sized gravel, with cobbles and silt, at and just below the Bonneville shoreline; up to 30 feet (9 m) thick.

Qls Lacustrine sand (latest Pleistocene) - Unconsolidated sand, with clay, silt, and gravel; located below the Bonneville shoreline; up to 30 feet thick (9 m).

Qlm Lacustrine marl (latest Pleistocene) - Unconsolidated, light-colored marl, and lesser clay, silt, and sand; includes ostracode- and gastropod-rich layers; exposed thickness 6 feet (2 m).

Qaf_2 Intermediate-age alluvial-fan deposits (late to middle Pleistocene) - Unconsolidated, poorly sorted clay, silt, sand, pebbles, cobbles, and boulders above the Bonneville shoreline; fan surfaces are inactive and undergoing erosion, and up to 20 feet (6 m) above modern drainages; generally less than 20 feet (<6 m) thick.

QTaf Older alluvial-fan deposits (early Pleistocene and Pliocene[?]) - Unconsolidated to semi-consolidated, poorly sorted clay, silt, sand, pebbles, cobbles, and boulders on the west flank of Keg Mountain above the Bonneville shoreline; original fan surfaces degraded and up to 60 feet (18 m) above modern drainages; at least 60 feet (18 m) thick. Designated as Qlg/QTaf where the deposit has been eroded and reworked by Lake Bonneville.

Topaz Mountain Rhyolite (Miocene) - Divided into:

Ttm Rhyolite flows, domes, and intrusions - White, gray, and purple rhyolite containing sparse (10 to 15 percent), small (0.08 inch [2 mm]) phenocrysts of quartz and sanidine, and lesser plagioclase, biotite, and opaque mineral phenocrysts in a matrix of devitrified glass; black to brown vitrophyre at the base of some flows and domes; less than 6.7±0.3 Ma; maximum exposed thickness 590 feet (180 m).

Ttmt Stratified tuff - Pale-tan to orange, very thick- to thin-bedded, nonwelded, lithic-rich rhyolitic tuff and volcanic sandstone; contains a variety of volcanic rock fragments, abundant pumice clasts, and sparse crystal fragments in an ash matrix; occurs as discontinuous water-laid and air-fall lenses beneath many rhyolite lava flows and domes; extensively zeolitized and feldspathically altered; up to 140 feet (43 m) thick.

Td Dell Tuff (Oligocene) - Pink to tan, poorly to moderately welded, crystal-rich, rhyolitic ash-flow tuff; contains abundant 0.1 to 0.4 inch (2 to 10 mm) phenocrysts of quartz, sanidine, plagioclase, and biotite; up to 19 % lithic fragments; dated 32.0±0.6 Ma (average) by Lindsey (1982); maximum exposed thickness 350 feet (110 m), but maximum exposed thickness is 600 (180 m) in the Keg Mtn. Ranch quadrangle.

Trp Rhyolite porphyry (Oligocene) - Small, pale-gray to pink, light-tan weathering, rhyolite porphyry dikes and plugs with large (up to 0.4 inch [1 cm]) phenocrysts of sanidine, quartz, plagioclase, and biotite in an aphanitic matrix; phenocrysts nearly absent near the margins of intrusions and become more abundant toward the interior; dated by Shubat and Snee (1992) at 35.14±0.15 Ma.

Tj Joy Tuff (Oligocene) - Red-brown to pink, moderately to densely welded, rhyolitic ash-flow tuff; black vitrophyre locally present at base of unit and overlain by a black fiamme-rich zone; contains abundant, 0.04- to 0.31-inch (1- to 8-mm) phenocrysts of quartz, sanidine, plagioclase, and biotite, and as much as 14 percent lithic clasts; dated by Shubat and Snee (1992) at 34.88±0.06 Ma; maximum exposed thickness 80 feet (24 m), but maximum exposed thickness is 540 feet (160 m) in Picture Rock Hills quadrangle.

Tqm Quartz monzonite (Oligocene and Eocene) - One or two, small, gray, rusty-weathering, porphyritic plug(s) containing 0.01- to 0.4-inch (0.3- to 10-mm) phenocrysts of plagioclase, biotite, quartz, hornblende, and potassium feldspar in a fine-grained matrix of potassium feldspar and quartz; contains sparse dark-green xenoliths; locally silicified and pyritized; not dated, but younger than Mt. Laird Tuff.

Tpd Pebble dike (Oligocene and Eocene) - Small pipe containing argillized and iron-stained clasts of volcanic rocks, Paleozoic rocks, and intrusive rocks; matrix poorly exposed; not dated; but younger than Mt. Laird Tuff in Keg Mtn. Ranch quadrangle.

Tdp Dacite porphyry (Oligocene and Eocene) - Small plugs of olive-green, propylitized dacite porphyry containing abundant, 0.08 to 0.4 inch (2 to 10 mm) phenocrysts of plagioclase, quartz, biotite, and hornblende in a fine-grained to aphanitic matrix; contains microphenocrysts of plagioclase, quartz and sanidine; dated by Shubat and Snee (1992) at 36.49±0.15 Ma and in this report at 36.2±1.4 Ma.

Tml Mt. Laird Tuff (Oligocene and Eocene) - Lavender, pale-green, dark-green, and brown, moderately welded, dacitic ash-flow tuff, tuff-breccia and lapilli-tuff, and probable lava flows and hypabyssal intrusions; characterized by abundant, 0.08 to 0.47 inch (2 to 12 mm) phenocrysts of white plagioclase; other phenocrysts are hornblende, biotite, quartz, and clinopyroxene; vitrophyre locally present at base; dated by Shubat and Snee (1992) at 36.54±0.06 Ma; maximum exposed thickness 220 feet (67 m).

Tgd Granodiorite porphyry (Oligocene and Eocene) - Light-olive-green to pinkish-green, holocrystalline stock containing 0.08 to 0.47 inch (2 to 12 mm) phenocrysts of plagioclase, quartz, biotite, hornblende, and clinopyroxene in a matrix of fine-grained quartz, plagioclase, and potassium feldspar; pervasive propylitic alteration; dated by Lindsey (1982) at 36.6±1.6 Ma.

Tk Keg Tuff* (Oligocene and Eocene) - Dark red-brown to black, densely welded, moderately crystal-rich, dacitic ash-flow tuff; black vitrophyre locally present at base and locally within the unit separating cooling units; abundant, bronze-weathering biotite prominent on surfaces parallel to layering; also contains plagioclase, biotite, quartz, and hornblende phenocrysts; dated by Shubat and Snee (1992) at 36.77±0.12 Ma; maximum exposed thickness 540 feet (165 m).

Dead Ox Tuff* (Oligocene and Eocene) - Divided into:

Tdo Lithic-crystal, ash-flow tuff member - Tan, orange, and pale-green, thick-bedded, moderately to poorly welded, dacitic ash-flow tuff; contains abundant lithic fragments, 0.04 to 16 inches (0.1 to 40 cm) in diameter, of quartzite, limestone, black phyllite, andesite, and pumice; slightly flattened pumice fragments impart a crude layering to the rock; phenocrysts consist of plagioclase, quartz, and biotite; argillic alteration common; coarse, lithic-rich parts weather to cobble- and boulder-strewn slopes, with little exposed matrix; maximum exposed thickness 60 feet (20 m).

Tdom Megabreccia member - Clasts of Prospect Mountain Quartzite, Pioche Formation, undifferentiated Lower Paleozoic limestone, conglomerate, andesitic lahar, and andesite in a poorly exposed matrix of poorly welded tuff similar to the lithic-crystal, ash-flow tuff member; clasts are less than 1 foot to 800 feet (<20 cm to 240 m) in diameter, most are 10 to 200 feet (3 to 60 m) in diameter; nearly all quartzite and some limestone clasts are intensely and pervasively brecciated, often supported with a fine-grained matrix of comminuted material; not dated, intruded by dacite porphyry and contains clasts of andesite of Keg Pass; maximum exposed thickness 280 feet (85 m).

Tdow Stratified tuff member - Poorly exposed, tan to orange, thin-bedded to laminated volcanic sandstone and siltstone, and tuff; sand-sized crystal fragments consist of quartz, plagioclase, and biotite; lithic fragments consist of quartzite, limestone, and volcanic rock; argillic alteration common; not dated, but intruded by dacite porphyry and overlies andesite of Keg Pass; apparently less than 40 feet (12 m) thick.

Tap Andesite porphyry (Eocene) - Small plugs of dark-brown to black, brown-weathering andesite porphyry containing phenocrysts of plagioclase, biotite, hornblende, and quartz in an aphanitic matrix; chemically dacitic; not dated but intrudes andesite of Keg Pass and overlain by Keg Tuff.

Ta Andesite of Keg Pass (Oligocene and Eocene) - Heterogeneous, dark-colored flows and less abundant lahars; flows contain phenocrysts of andesine, biotite, hornblende, quartz, clinopyroxene, and magnetite in a trachytic matrix; some flows contain plagioclase crystals as long as 0.6 inches (15 mm); lahar commonly at base of unit and contains clasts of andesite, quartzite, limestone, and (locally) Mt. Laird Tuff; propylitic alteration common; age variable but as old as 39 and as young as 37 million years old; maximum exposed thickness 200 feet (60 m).

TKc Unnamed conglomerate (Tertiary and/or Cretaceous) - Consists of well-rounded pebbles and cobbles of quartzite, chert, and limestone in a gray-green, sandy to silty matrix; poorly exposed; maximum exposed thickness 40 feet (12 m).

Ꞓl Undifferentiated Cambrian carbonate rocks - Light- to dark-gray, medium- to thick-bedded, biosparite limestone with minor shale and intraformational conglomerate interbeds; exposed in footwall of thrust faults; correlation uncertain, but is probably part of the Middle Cambrian Howell Limestone, Chisholm Formation, Dome Limestone, Whirlwind Formation, or Swasey Limestone; exposed thickness up to 200 feet (60 m).

Ꞓh Howell Limestone (Cambrian) - Light- to medium-gray, medium- to thick-bedded, biosparite limestone; in the Table Mountain quadrangle contains intercalations of olive-green-gray phyllite at the base of the unit; estimated thickness 400 feet (120 m).

Pioche Formation (Cambrian) - Divided into:

Ꞓpt Tatow Member - Thick- to medium-bedded, mottled orange-brown, oncolitic dolomite and white to gray oncolitic limestone; forms low cliffs; thickness uncertain, but up to 94 feet (29 m) measured in Slow Elk Hills.

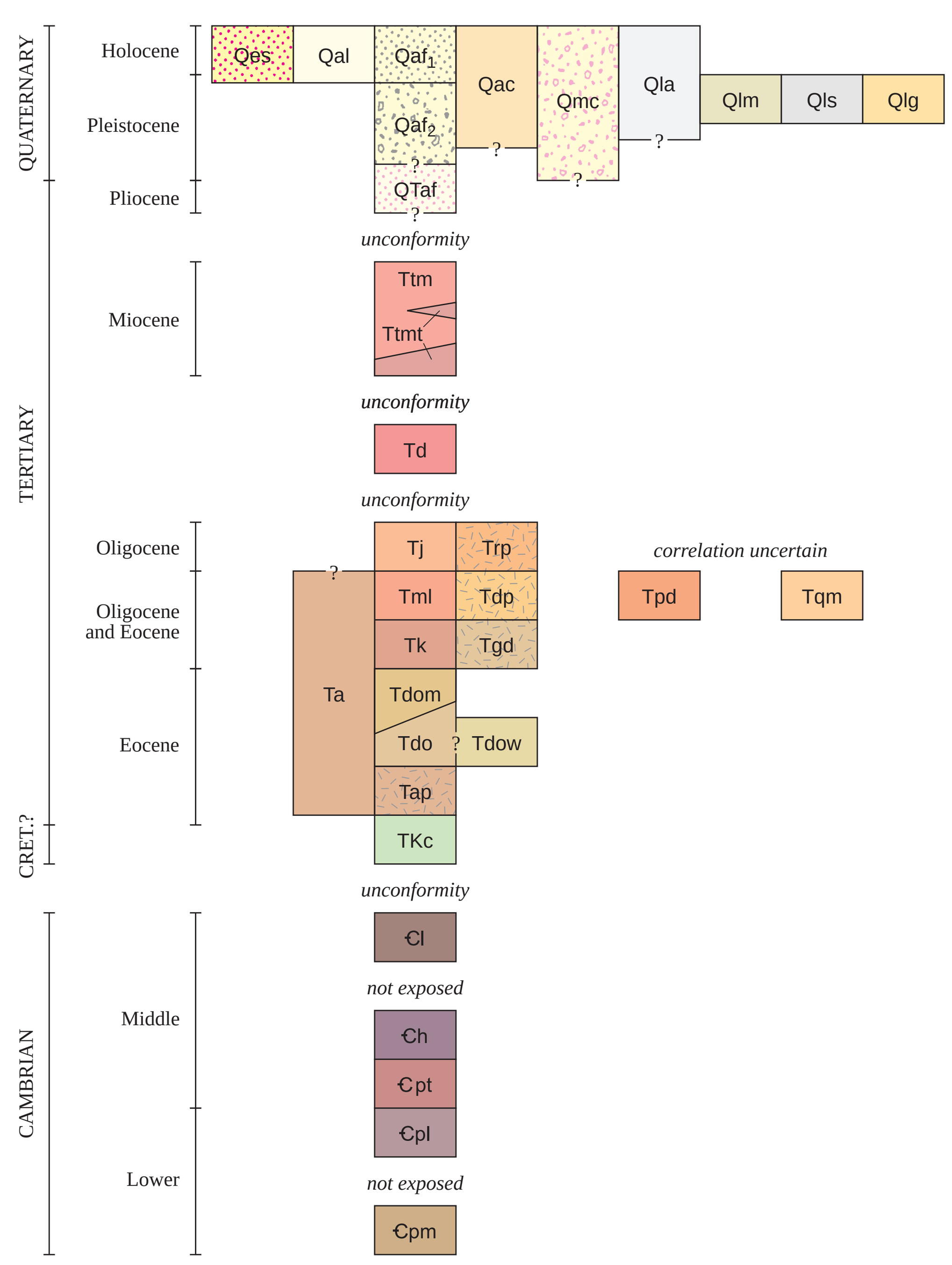
Ꞓpl Lower member - Contains medium-bedded, dark-green to black, ledge-forming quartzite, thin-bedded, dark-olive-green to black phyllitic quartzite, and dark-olive-green phyllite; occurs as thin slivers between thrust faults; quartzite dominates in the lower part and phyllite in the upper part; rusty weathering; thickness uncertain, but 287 feet (88 m) measured in Slow Elk Hills isn't a maximum thickness.

Ꞓpm Prospect Mountain Quartzite (Cambrian) - Pinkish-gray to tan, rusty-weathering, medium-grained, thick-bedded quartzite with small-scale cross-bedding in the upper plate of a thrust fault; pervasively brecciated in most exposures; thickness uncertain, but estimated at 820 feet (250 m) in the Slow Elk Hills.

STRATIGRAPHIC COLUMN

SYSTEM	SERIES	FORMATION / MAP UNIT	SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
QUAT.	Holocene / Pleistocene	Quaternary deposits	Q	0-30 (0-9)	
TERTIARY	Pliocene	Older alluvial-fan deposits	QTaf	0-60+ (0-18+)	unconformity
TERTIARY	Miocene	Topaz Mountain Rhyolite: Rhyolite flows, domes, and intrusions	Ttm	0-590 (0-180)	Ttmt
TERTIARY	Miocene	Topaz Mountain Rhyolite: Stratified tuff	Ttmt	0-140 (0-43)	unconformity
TERTIARY	Oligocene	Dell Tuff	Td	0-350 (0-110)	~32-34 Ma; unconformity
TERTIARY	Oligocene	Joy Tuff	Tj	0-80 (0-20)	Avg. 34.88 ± 0.06 Ma
TERTIARY	Oligocene	Mt. Laird Tuff	Tml	0-220 (0-67)	Avg. 36.54 ± 0.06 Ma
TERTIARY	Oligocene	Keg Tuff	Tk	0-540 (0-160)	36.77 ± 0.12 Ma Ar-Ar
TERTIARY	Oligocene and Eocene	Dead Ox Tuff: Megabreccia member	Tdom	0-280 (0-85)	
TERTIARY	Oligocene and Eocene	Dead Ox Tuff: Lithic-crystal tuff mbr	Tdo	0-60 (0-18)	
TERTIARY	Oligocene and Eocene	Dead Ox Tuff: Stratified tuff mbr	Tdow	0-40 (0-12)	not exposed
TERTIARY and CRETACEOUS	Oligocene and Eocene	Andesite of Keg Pass	Ta	0-200 (0-60)	~37-40 Ma, but see correlation chart for probable range in age of Andesite of Keg Pass
TERTIARY and CRETACEOUS		Unnamed conglomerate	TKc	0-40 (0-12)	unconformity
CAMBRIAN	Middle	Undifferentiated carbonate rocks	Ꞓl	200 (60)	
		not exposed			
CAMBRIAN	Middle	Howell Limestone	Ꞓh	400+ (120+)	Thrust sheet-overlies younger Cambrian unit
CAMBRIAN	Middle	Pioche Fm.: Tatow Member	Ꞓpt	94 (29)	
CAMBRIAN	Lower	Pioche Fm.: Lower member	Ꞓpl	287+ (88+)	
		not exposed			
CAMBRIAN	Lower	Prospect Mountain Quartzite	Ꞓpm	820+ (250+)	Thrust sheet-overlies younger Cambrian units

CORRELATION OF GEOLOGIC UNITS



MAP AND CROSS SECTION SYMBOLS

- Contact, dotted where covered, dashed and queried on cross sections where diagrammatic.
- High-angle fault, dashed where location inferred, dotted where covered, bar and ball on downthrown side, dip indicated where measured, arrows show direction of movement on cross sections, dashed and queried on cross sections where diagrammatic.
- Thrust fault, dotted where covered, teeth on upper plate, dashed and queried on cross sections where diagrammatic.
- Air-photo lineament, probable location of high-angle fault.
- Anticlinal axis, dotted where covered.
- Synclinal axis, dotted where covered.
- Bonneville shoreline
- Provo shoreline
- A A′ Line of cross section
- 25 Strike and dip of bedding
- vertical, 70 Strike and dip of layering in volcanic rocks
- Dike
- KP-6-5 Location of sample analyzed in this study (results in table 1 and appendices)
- Prospect