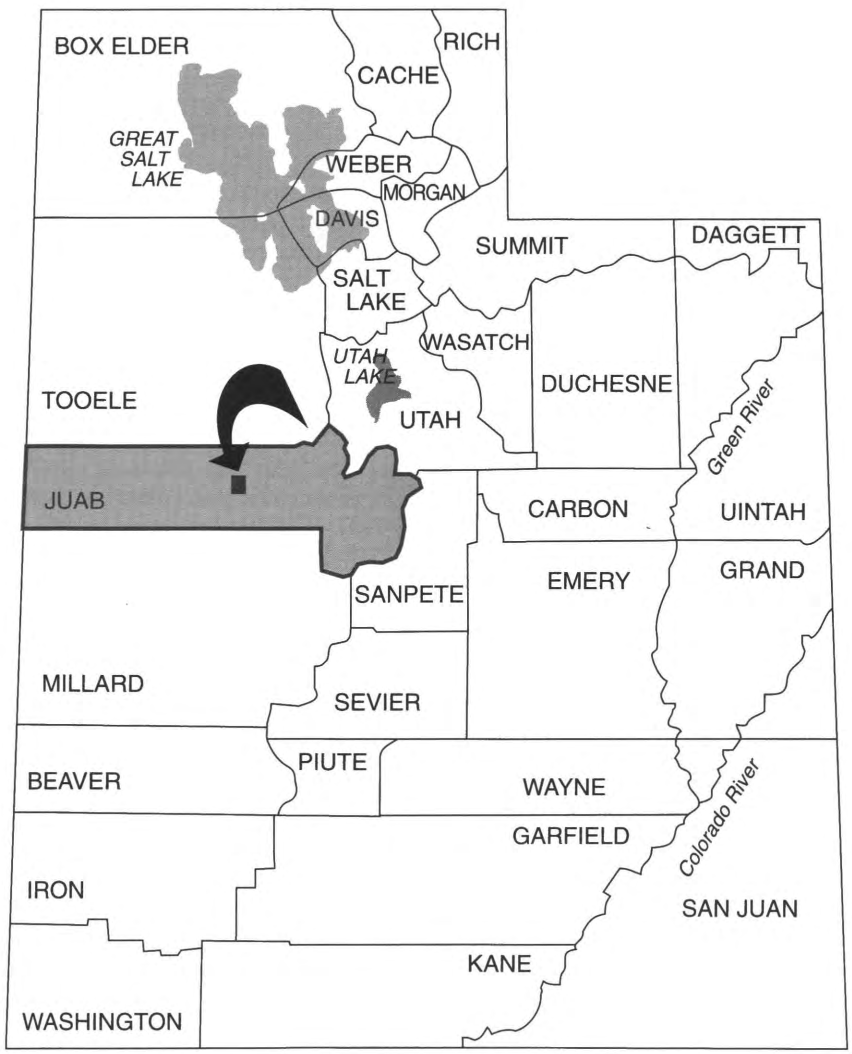
GEOLOGIC MAP OF THE KEG MOUNTAIN RANCH QUADRANGLE, JUAB COUNTY, UTAH

by
Michael A. Shubat, Tracey J. Felger, and Jon K. King



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ABSTRACT

The Keg Mtn. Ranch 7.5′ quadrangle is in west-central Utah and includes the eastern 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 thrust faults and folds that are exposed in adjacent quadrangles. Most of the quadrangle is underlain by Tertiary volcanic and intrusive rocks. Several calderas and cauldrons are in and near the Keg Mtn. Ranch 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 volcanic units of this age in the quadrangle (and sources) are, from oldest to youngest: the Keg Tuff (Keg cauldron); Mt. Laird Tuff (Thomas caldera); Joy Tuff (Dugway Valley cauldron); and Dell Tuff (unknown source). Late Miocene rhyolite of Keg Mountain and Topaz Mountain Rhyolite were erupted from scattered local vents. Lake Bonneville covered much of the quadrangle during the late Pleistocene and produced most of the surficial deposits. The lake left distinctive sediments and landforms, including marl, V-bars of the "Snow Plow," and prominent Bonneville and Provo shorelines. Other surficial deposits include stream alluvium, colluvium, and several generations of alluvial fan deposits. Potential mineral resources in the quadrangle include gold, sand and gravel, cement rock, high-calcium limestone, zeolites, crushed stone, and dimension stone.

INTRODUCTION

The Keg Mtn. Ranch quadrangle is in north-central Juab County, Utah, approximately 38 miles (61 km) northwest of Delta, Utah (figure 1). The quadrangle includes the eastern part of Keg Mountain, a low range in the Great Basin located between the Thomas Range to the west, the Simpson Mountains to the northeast, and Desert Mountain to the east. Bedrock geologic mapping by Shubat of the Utah Geological Survey (UGS) was conducted as part of a U.S. Geological Survey (USGS) mineral assessment of the Delta 1° x 2° quadrangle. Bedrock geology in this report was examined by Shubat from 1986 through 1991, and is a refinement of the information presented in Shubat (1987) and Shubat and Snee (1992). Quaternary geologic mapping of the Keg Mtn. Ranch quadrangle was done by Felger (USGS) in 1990 and 1991 as part of a UGS-USGS funded Cooperative Geologic Mapping (COGEOMAP) project on the Quaternary geology of the Old River Bed, northern Sevier Desert (Oviatt and others, 1994a). In 1995, King resolved discrepancies between these investigations on the Keg Mtn. Ranch quadrangle and published reports by Shubat and Christenson (1999), Shubat (1999), and Oviatt and others (1994a).

Previous investigations of the bedrock geology of 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) geologic map of the Picture Rock Hills 7.5′ quadrangle, which covers the southwestern portion of Keg Mountain. Morris (1978) reported hydrothermally altered rocks in the Keg Pass 7.5′ quadrangle, and conducted a reconnaissance study 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. As a result of this work, 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 the Miocene igneous rocks in the Keg Mtn. Ranch 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.

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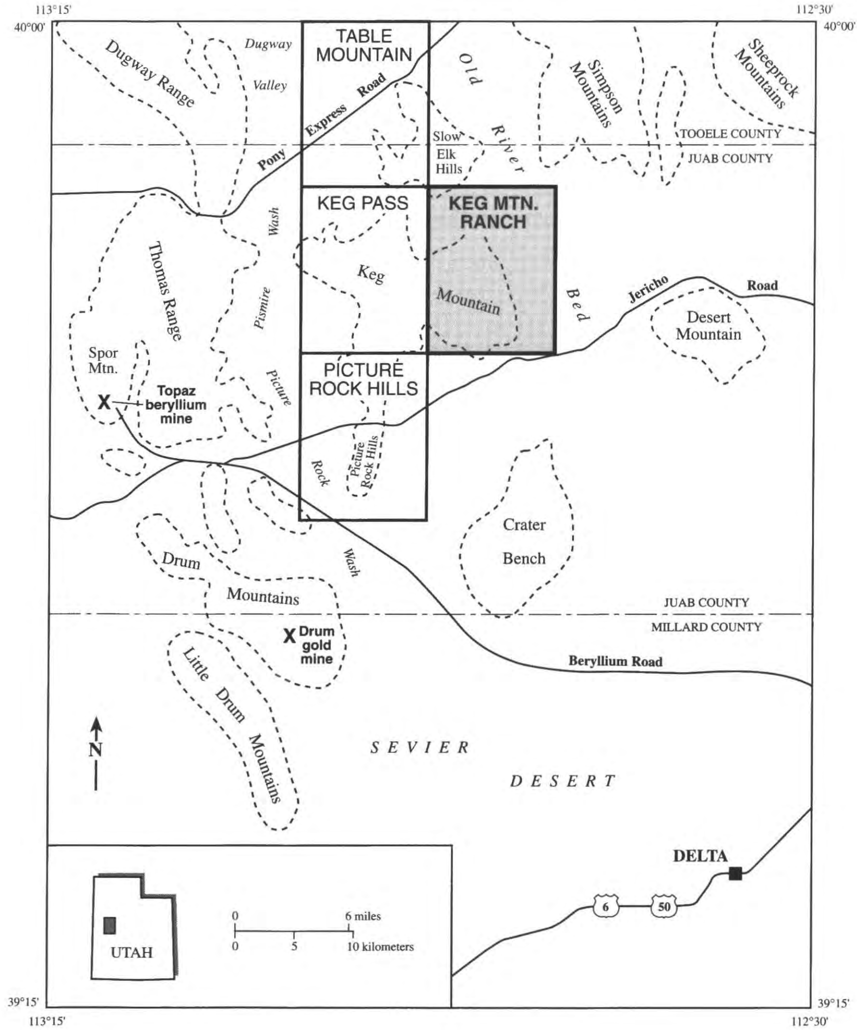

Figure 1. *Index map showing the location of the Keg Mountain Ranch and adjacent quadrangles. The name Keg Mtn. Ranch is used for the map name.*

Shubat and Christenson (1999) and Shubat (1999) mapped the adjacent Keg Pass and Picture Rock Hills 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, 1994a).

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. Deformed Cambrian rocks are exposed in the adjacent Keg Pass and Table Mountain 7.5′ quadrangles but are almost completely covered in the Keg Mtn. Ranch quadrangle. 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 (Shubat and Christenson, 1999).

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 (Shubat and Christenson, 1999). 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 in the Drum Mountains district (Nutt and others, 1991) and may include polymetallic vein, polymetallic replacement, and gold occurrences at Keg Mountain (Shubat, 1987; Shubat and Christenson, 1999).

The middle stage (early Oligocene) consisted of eruptions of rhyolitic ash-flow tuffs, with attendant caldera subsidence, and intrusion of felsic stocks and plugs. In the Thomas Range, Lindsey (1982) correlated 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 rhyolite of Keg Mountain and Topaz Mountain Rhyolite were 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 fluorspar and uranium occurrences in the Thomas Range (Staatz and Carr, 1964; Lindsey, 1982).

Quaternary

Exposed Quaternary sediments were mostly deposited in Lake Bonneville. Prior to Lake Bonneville, Quaternary deposits were chiefly alluvium, colluvium, and alluvial-fan deposits. In addition, late Pliocene and Pleistocene lake beds are present to the south near Crater Bench (figure 1) and may be present in subsurface in the Old River Bed area (Oviatt and others, 1994a). During and following the retreat of latest Pleistocene Lake Bonneville, these sub-aerial processes continued and eolian reworking of the lake deposits occurred.

About 30,000 years ago Lake Bonneville began transgressing the Great Salt Lake basin, rising from levels similar to those of present-day Great Salt Lake (Oviatt and others, 1992). During this time an unnamed, freshwater lake was transgressing in the Sevier Desert basin (Oviatt, 1989). The two basins were separated by a threshold in the Old River Bed in or near Keg Mtn. Ranch quadrangle at an elevation of about 4,560 feet (1,390 m); this paleo-threshold is now concealed by Holocene deposits. The unnamed lake in the Sevier Desert basin began overflowing this threshold into the Great Salt Lake basin about 27,000 years ago (Oviatt, 1989). About 21,000 years ago, Lake Bonneville rose to the level of the threshold, and then continued to transgress, occupying the Sevier Desert basin (Oviatt, 1989; Oviatt and others, 1994a). Lake Bonneville reached a highstand elevation of about 5,220 feet (1,591 m) (includes isostatic rebound) in the quadrangle (Currey, 1982; this report) approximately 15,000 years ago (Oviatt and others, 1992). Keg Mountain and the Picture Rock Hills were islands at this time (Currey and others, 1984). The lake remained at this level for about 500 years, creating the Bonneville shoreline. About 14,500 years ago, an alluvial dam in Idaho was breached (Oviatt and others, 1994a), and the lake level dropped to an elevation of about 4,820 feet (1,469 m), including rebound, in the quadrangle (Currey, 1982; this report). Lake Bonneville remained at this level until about 14,000 years ago, creating the Provo shoreline. At this time, the lake began a climate-controlled regression (Oviatt and others, 1992). Once the elevation of the Old River Bed threshold was reached, Lake Gunnison occupied the Sevier Desert basin (controlled by the Old River Bed threshold) and Lake Bonneville occupied the Great Salt Lake basin (Oviatt and others, 1994a).

Keg Mountain Oscillation

The defining locality for the Keg Mountain oscillation (Currey and others, 1983) is on the east side of Keg Mountain (KMO, plate 1). At this locality, exposures of lacustrine, fine-grained sediments and gravel were interpreted by Currey and others (1983) as evidence for a non-catastrophic drop in lake level that Currey (1980) first proposed had occurred during the Bonneville highstand. Based on the Keg Mountain exposures, Currey and others (1983) suggested that Lake Bonneville regressed from the Bonneville shoreline approximately 130 to 165 feet (40 to 50 m), and then transgressed back to the Bonneville shoreline before the Bonneville flood.

Oviatt and others (1994a) re-evaluated the locality and concluded that the exposures are not adequate to demonstrate the existence of the Keg Mountain oscillation, as defined by Currey and others (1983). Oviatt and others (1994a) presented details and hypothesized that an oscillation in lake level occurred while the lake was transgressing to the Bonneville shoreline.

MAP UNITS

Cambrian

Cambrian units are incompletely exposed in the northwest part of the Keg Mtn. Ranch quadrangle. Their identification and age is based on the work of Hintze and Robison (1975), and on better exposures to the west and north in the Keg Pass quadrangle and Slow Elk Hills, respectively.

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. The quartzite is only exposed in the northwest corner of the quadrangle, and is pervasively brecciated in most exposures. Exposed quartzites are probably in the upper plate of a thrust fault, like exposures in the adjacent Keg Pass quadrangle; neither the upper nor lower contacts of the unit are exposed. Just northwest of the quadrangle in the Slow Elk Hills (figure 1), the Prospect Mountain Quartzite conformably underlies the Pioche Formation. 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 of the Prospect Mountain Quartzite in the Slow Elk Hills to be about 820 feet (250 m). The exposed thickness in the Keg Mtn. Ranch quadrangle is 80 feet (24 m).

Undifferentiated Cambrian Carbonate Rocks (€l)

Undifferentiated Cambrian carbonate rocks consist of light- to dark-gray, medium- to thick-bedded biosparite in four small exposures that are surrounded by volcanic rocks (sections 20 and 21, T. 11 S., R. 9 W.) (all locations in this report are Salt Lake Baseline and Meridian). These rocks are probably part of the Middle Cambrian Howell Limestone, Chisholm Formation, Dome Limestone, Whirlwind Formation, or Swasey Limestone (after Morris, 1987). Similar carbonate rocks in the Keg Pass quadrangle are at least 200 feet (60 m) thick (Shubat and Christenson, 1999) and are in the footwall of thrust faults. Exposures in the Keg Mtn. Ranch quadrangle are less than 20 feet (6 m) thick.

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 Streckeisen (1976, 1978)(figure 3) and whole-rock, major-element chemical analyses (appendix B) using total-alkali-silica (TAS) plots of Le Bas and others (1986)(figure 4). Some samples and units shown on the figures are from or only exposed in the adjacent Keg Pass and Picture Rock Hills quadrangles. Analyses of samples from these adjacent quadrangles are also included in the appendices. Plate 1 shows the locations of samples collected from the Keg Mtn. Ranch quadrangle for modal and major-element chemical analyses. Informal map-unit names are based on these classifications, lithology, and general outcrop locations. We also define vent areas for several units (see structure section). Dates on Tertiary rocks are summarized in table 1, and 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 plate 1 and figure 2.

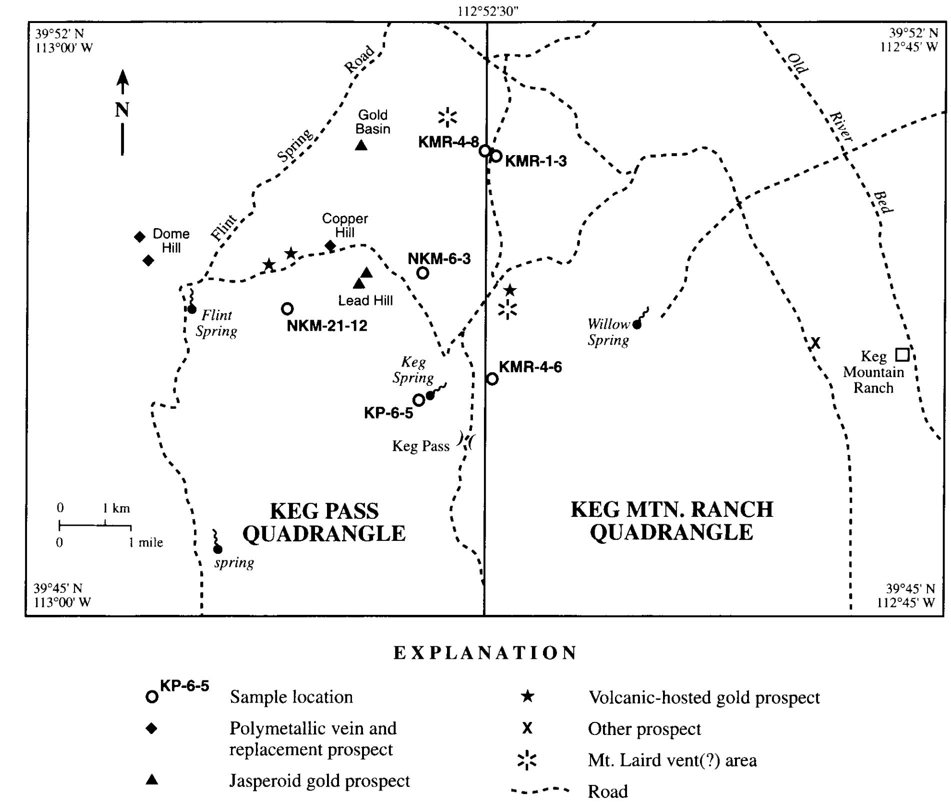

Figure 2. *Locations of samples dated by Shubat and Snee (1992)(see table 1), possible Mt. Laird vent areas, and mineral occurrences at Keg Mountain.*

Erickson (1963) originally described and informally named the oldest igneous rocks in Keg Mountain as the "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 (1963) "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" unit 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.

Mapping by Shubat and Christenson (1999), Shubat (1999), and in this study show 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 units including: andesite of Keg Pass, Keg Tuff, Mt. Laird Tuff, and several intrusive units. In this report, we use the informal name "andesite of Keg Pass" for heterogeneous flows and intercalated lahars in the quadrangle.

Andesite of Keg Pass (Ta)

The andesite of Keg Pass consists of a heterogeneous sequence of dark-colored, dacitic, latitic, and andesitic flows and lahars in the northwest part of the quadrangle. 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 up to 0.59 inches (15 mm) long. Lahars commonly occur at the base of the unit and contain clasts of andesite, quartzite, limestone, and locally Mt. Laird Tuff.

Widespread propylitic alteration (in varying degrees of intensity) of the unit is seen in mineralogic changes; plagioclase has been 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.

Modal analysis of one sample (figure 3 and appendix A) shows that, based on phenocryst composition, the rock is an andesite. However, figure 4 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, it is darker than most latites and dacites in the area, and the phenocryst content can be mapped in the field.

No complete section of the andesite of Keg Pass is exposed in the quadrangle. The maximum exposed thickness of the unit is about 200 feet (60 m).

The andesite of Keg Pass appears to overlie the Keg Tuff at their only exposed contact in the quadrangle (section 8-9 line, T. 12 S., R. 9 W.). However, examinations by Shubat and Christenson (1999) and Shubat for this study show that the age of this andesite unit spans the ages of the Keg and Mt. Laird Tuffs and several other units. Samples that are apparently from the andesite of Keg Pass, collected in the eastern part of the Keg Pass quadrangle, reportedly have an average age of 39.4 ± 0.7 Ma (table 1). In the Keg

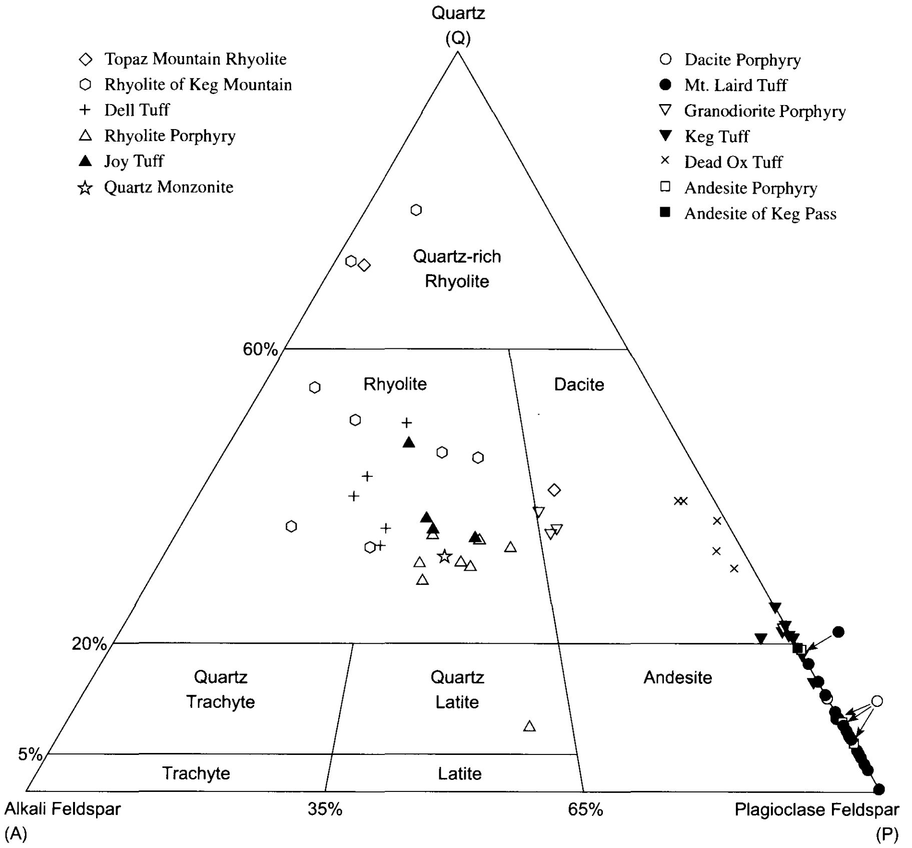

Figure 3. *Modal analyses of igneous rocks from Keg Mountain and the Picture Rock Hills plotted on a trilinear QAP diagram. Q is the quartz content, A is the alkali feldspar content, and P is the plagioclase content as determined by point counting grains in holocrystalline rocks and phenocrysts in aphanitic 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 the quadrangle (see appendix).*

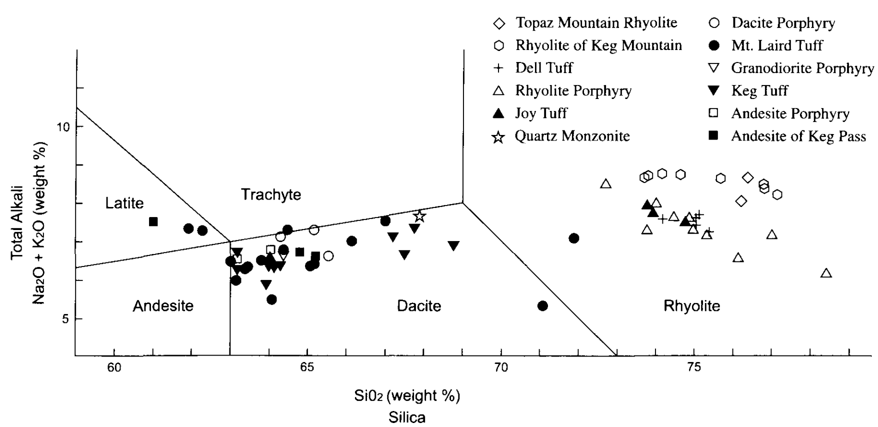

Figure 4. *Total alkali ($Na_2O + K_2O$) versus silica (SiO_2) (TAS) diagram for igneous rocks at Keg Mountain and the Picture Rock Hills. Compositional fields for volcanic rocks from Le Bas and others (1986). Appendix B lists the major element whole-rock geochemical analyses. Not all rock types shown and listed are exposed in this quadrangle (see appendix).*

Pass quadrangle, the andesite of Keg Pass underlies the Keg Tuff (36.77 ± 0.12 Ma, table 1)(Shubat and Christenson, 1999), and in this quadrangle (section 27, T. 11 S., R. 9 W.) clasts of Mt. Laird Tuff (36.54 ± 0.06 Ma, table 1) occur in the lahar facies of the andesite of Keg Pass.

Keg Tuff (Tk)

Shubat and Christenson (1999) named the Keg Tuff and designated the type locality in the Keg Pass quadrangle. 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, dacitic, ash-flow tuff. Exposures in the Keg Mtn. Ranch quadrangle are near the center of the western margin. A black vitrophyre occurs locally at the base of the Keg Tuff. Abundant bronze-weathering biotite is prominent on surfaces parallel to layering. Phenocrysts are 0.04 to 0.24 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. Nine modal analyses (figure 3 and appendix A) and whole-rock chemical analyses of three of these samples and seven other samples (figure 4 and appendix B) indicate that the Keg Tuff is a dacite. An incomplete section of the Keg Tuff in the west-central part of the Keg Mtn. Ranch quadrangle is about 200 feet (60 m) thick. The Keg Tuff is about 540 feet (165 m) thick near the type section in the Keg Pass quadrangle (Shubat and Christenson, 1999). From these and other data the Keg Tuff was probably erupted onto an irregular paleotopography (see Shubat and Christenson, 1999). The Keg Tuff has been dated at 36.77 ± 0.12 Ma (table 1).

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. Shubat and Christenson (1999) proposed that it was erupted from a poorly defined cauldron, the Keg cauldron (see structure section), best defined in the south and north parts of the Keg Pass and Picture Rock Hills quadrangles, respectively (figure 5). Shubat and Christenson (1999) considered the Keg Tuff comagmatic with granodiorite porphyry, exposed to the west in the Keg Pass (Shubat and Christenson, 1999) and Picture Rock Hills (Shubat, 1999) quadrangles.

Mt. Laird Tuff (Tml)

Lindsey (1979) named the Mt. Laird Tuff for exposures near Mt. Laird in the nearby Thomas Range, and reported

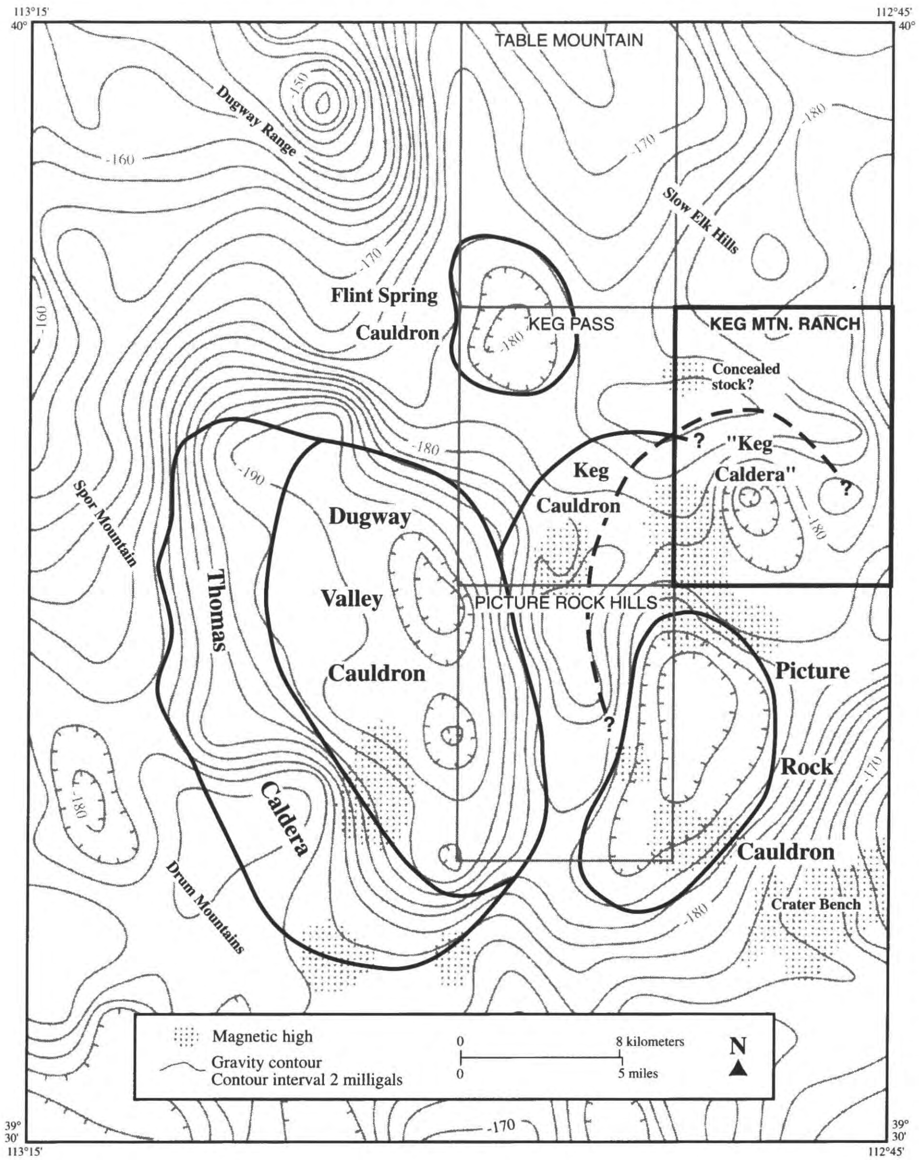

Figure 5. Locations of proposed calderas and cauldrons at Keg Mountain and surrounding areas. Gravity data from Bankey and Cook (1989). Magnetic highs from data in Kucks (1991). Caldera margins in the Thomas Range from Lindsey (1982).

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, and lapilli-tuff of dacitic composition. Probable lava flows and hypabyssal intrusions were mapped with the Mt. Laird Tuff in the Keg Mtn. Ranch and Keg Pass quadrangles, because they had similar appearance and dacitic composition, and could only be distinguished in thin section. All Mt. Laird rock types are exposed on the west margin of the Keg Mtn. Ranch quadrangle. 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 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 occurs locally at the base of the unit. A volumetrically minor facies is an accretionary lapilli, block tuff with a distinctive black, aphyric matrix that also contains the accretionary lapilli. 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.

Modal analyses of 25 samples (figure 3 and appendix A) indicate that, based on phenocryst content, these rocks would be named andesite. Figure 4, 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. No complete section of the Mt. Laird Tuff is exposed in the quadrangle; the maximum exposed thickness of the Mt. Laird Tuff is 240 feet (73 m).

The Mt. Laird Tuff has a reported average age of 36.54 ± 0.06 Ma (table 1). Biotite from one of the samples used for $^{40}Ar/^{39}Ar$ dating yielded a K-Ar date of 37.1 ± 1.5 Ma (Geochron Laboratories; table 1). In the Drum Mountains, Lindsey (1982) reported a fission-track date of 36.4 ± 1.6 Ma for the Mt. Laird Tuff, but because of field relations and dates on other units he considered its true age to be about 39 million years old. We believe the Mt. Laird Tuff is close to 36.5 million years old 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 Mt. Laird Tuff.

Lindsey (1982) correlated the eruption of the Mt. Laird Tuff with collapse of the Thomas caldera (figure 5; see structure section). Over most of the Keg Mtn. Ranch quadrangle, the unit appears to be outflow from the Thomas caldera.

Vents for lavas, and possibly some related tuffs, mapped with the Mt. Laird Tuff may be present in the northeast

Table 1. *Summary of dates for igneous rocks at Keg Mountain. Figure 2 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 ± 0.061	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		Shubat & Christenson, 1992
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		Shubat & Christenson, 1992
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

part of the Keg Pass (sections 17 and 20, T. 11 S., R. 9 W.) and west-central part of the Keg Mtn. Ranch quadrangle (section 33, T. 11 S., R. 9 W., and section 4, T. 12 S., R. 9 W.)(figure 2). Vent(?) facies rocks "spill over" into adjacent areas (northwest Keg Mtn. Ranch and east-central Keg Pass quadrangles). Evidence for these vents are coarse fragmental textures in adjacent (related?) tuffs and block tuffs, steeply dipping layering, possible hypabyssal intrusions, and pebble dikes (Tpd) containing Mt. Laird clasts (this report; Shubat and Christenson, 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.

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 Keg Mtn. Ranch and Keg Pass quadrangles (figure 5). We interpret this anomaly as the manifestation of a concealed dacite porphyry stock because of its proximity to: (1) the possible lava vents described above (figure 2); and (2) several dacite porphyry plugs in the Keg Pass quadrangle that are the comagmatic, intrusive equivalents of the Mt. Laird Tuff (Shubat and Christenson, 1999). Audio-magnetotelluric (AMT) resistivity data support this interpretation (D.L. Campbell, verbal communication, 1990).

Two lines of evidence suggest that another concealed pluton underlies the southwest border of the quadrangle, mostly south of Keg Pass. 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 an area just south of Keg Pass, 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 south from Keg Pass for about 5 miles (8 km)(figure 5). This magnetic signature is consistent with many known intermediate intrusions in the Deep Creek-Tintic belt (Stewart and others, 1977). This postulated concealed intrusion might be a dacitic equivalent of the Mt. Laird Tuff, like the possible stock discussed in the previous paragraph. The concealed magnetic and resistive body might alternatively be due to some other intermediate composition rocks, in particular the granodiorite porphyry and related Keg Tuff in the Keg Pass quadrangle or andesite of Keg Pass.

Pebble Dikes (Tpd)

Two pebble dikes occur near the center of the western margin of the quadrangle (W½ section 33, T. 11 S., R. 9 W., and center NW¼ section 4, T. 12 S., R. 9 W.). The exposures are small, only about 200 feet (60 m) diameter, and are mostly in contact with alluvium. These bodies might be dikes or pipes given the concealed extent and circular exposures. The dikes contain argillized and iron-stained clasts of (in order of abundance) Tertiary volcanic rocks, Paleozoic sedimentary rocks, and Tertiary intrusive rocks. The matrix is not well exposed. The margins of the exposures, particularly those in section 4, are strongly argillized, pyritized, and iron stained. This pebble dike cuts Mt. Laird Tuff (Tml)(36.54 ± 0.6 Ma, table 1), indicating the maximum age of the unit. These bodies are similar to a pebble pipe in the adjacent Keg Pass quadrangle (section 8, T. 12 S., R. 9 W.), that cuts the andesite of Keg Pass (Ta)(39.4 ± 0.7 Ma, table 1).

Joy Tuff (Tj)

Lindsey (1979) named the Joy Tuff for exposures near the Joy townsite in the nearby 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 Tuff, Mt. Laird Tuff, and Dell Tuff.

Joy Tuff consists of red-brown to pink, distinctly red-weathering, moderately to densely welded, rhyolitic ash-flow tuff. Two exposures are present in the northwest part of the quadrangle. A black vitrophyre occurs at the base of the unit and a black, fiamme-rich zone overlies the vitrophyre. 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, intrusive, and sedimentary rocks. 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, though locally glassy. Phenocrysts are unaltered. Modal analyses (figure 3 and appendix A) and whole-rock chemical analyses of the same four samples (figure 4 and appendix B) show that these rocks are mostly rhyolite. 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).

A sample of basal vitrophyre of the Joy Tuff was dated at 34.88 ± 0.06 Ma (table 1). This date shows a marked difference with most of the fission-track ages (range 34.5 ± 1.3 to 39.7 ± 3.4) reported by Lindsey (1982) that average 38.0 ± 0.7 Ma. The Joy Tuff is probably close to 35 million years old, because (1) $^{40}Ar/^{39}Ar$ dating is more accurate than fission-track dating (Shubat and Snee, 1992), (2) unpublished $^{40}Ar/^{39}Ar$ age-spectrum dates from the type section of the Joy Tuff (C.J. Nutt, verbal communication, 1992) are compatible with this date, and (3) rhyolite porphyry (Trp), which appears to be comagmatic with the Joy Tuff (figures 3 and 4, appendices A and B), is 35.14 ± 0.15 Ma (table 1).

Lindsey (1982) believed the Joy Tuff was erupted from the Dugway Valley cauldron, located between Keg Mountain and Topaz Mountain (figure 5; see structure section). The small thickness of the Joy Tuff in the Keg Mtn. Ranch quadrangle (80 feet [24 m]) suggests that it is outflow from the cauldron. Closer to the source cauldron in the Picture Rock Hills quadrangle, the maximum exposed thickness is 540 feet (160 m), 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 in the Keg Mountain area occurs as many small, hypabyssal dikes and elongate plugs that form several linear, north- to east-trending zones described by Shubat and Christenson (1999). Only the northeastern end of the southern northeast-trending zone is present in the Keg Mtn. Ranch quadrangle. Rhyolite porphyry exposures are located in the central part of the west margin of the quadrangle.

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 than these early investigators. Pampeyan (1989) informally named the unit the quartz latite stocks of Keg Mountain.

Rhyolite porphyry consists of pale-gray to pink, light-tan weathering dikes and plugs with large (up to 0.4 inch [1 cm]) phenocrysts of sanidine, quartz, plagioclase, and biotite, lesser amounts of zircon and opaque minerals, and locally orthoclase. 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 shows 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 3 and appendix A) and whole-rock chemical analyses of six of these and four other samples (figure 4 and appendix B) show that these rocks are mostly rhyolite.

A rhyolite porphyry plug in the Keg Mtn. Ranch quadrangle was dated at 35.14 ± 0.15 Ma (table 1). Lindsey and others (1975) dated a rhyolite porphyry plug in the Keg Pass quadrangle at 30.8 ± 1.8 Ma. The rhyolite porphyry intrusions are probably about 35 million years old given the greater accuracy of the $^{40}Ar/^{39}Ar$ dating method (Shubat and Snee, 1992), and field relations in the Keg Pass quadrangle (Shubat and Christenson, 1999), where the Dell Tuff (Td) <33.8 ± 1.3 Ma, table 1) overlies rhyolite porphyry intrusions.

The rhyolite porphyry intrusions and the Joy Tuff are similar in many ways. The two units have similar phenocryst assemblages (figure 3, appendix A), chemical compositions (figure 4, appendix B), and nearly the same ages (table 1). For these reasons we consider the rhyolite porphyry to be a 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 that is exposed in the west half 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 inches (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 are less than 1 percent. The rock is unaltered. Modal analyses of five samples (figure 3 and appendix A), and whole-rock chemical analyses of three of these and two other samples (figure 4 and appendix B) show these rocks to be rhyolite. The Dell Tuff has a maximum exposed thickness of 600 feet (180 m) in the quadrangle, the thickest in the area, and may be thicker in subsurface.

Two samples of Dell Tuff from the Keg Pass quadrangle were dated at 32.5 ± 1.6, 33.6 ± 1.8 and 33.8 ± 1.3 Ma (table 1). Lindsey (1982) reported an average age of 32.0 ± 0.6 Ma for the formation in the Thomas Range, Drum Mountains and Keg Mountain. These dates are consistent with field relations in the Keg Pass quadrangle (Shubat and Christenson, 1999), where the Dell Tuff overlies rhyolite porphyry intrusions (Trp)(35.14 ± 0.15 Ma, table 1) and is unconformably overlain by the rhyolite of Keg Mountain and Topaz Mountain Rhyolite (6 to 10 million years old).

Paleomagnetic work 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 (J.L. Hanna, University of Vermont, verbal communication, 1989; Gutscher, 1989), suggesting the Dell Tuff has 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 its 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 5 (see also structure section) and was noted by Shubat (1999) as a possible source for the Dell Tuff.

Rhyolite of Keg Mountain

Erickson (1963) mapped rocks belonging to this informally named unit as part of his "Keg Mountain Ignimbrite." Shawe (1972), Lindsey and others (1975), and Morris (1987) mapped rocks in our unit as rhyolite of Keg Mountains and rhyolite of Keg Mountain. Morris (written communication, 1986) recognized that the unit contains flows, domes, and tuffs. Plavidal (1987) referred to our unit as the Keg Mountain rhyolites and separated the unit into five lithologies. Pampeyan (1989) showed most of our map unit as older rhyolite flows, plugs, and dikes of Keg Mountain.

In this report we use the informal name "rhyolite of Keg Mountain" and divide the unit into two informal members: (1) rhyolite flows, domes, and intrusions; and (2) stratified tuff. Beds of stratified tuff occur as discontinuous lenses beneath and between rhyolite flows and domes. Stratified tuff was probably in part explosively erupted from the same vents as, and possibly just before, the rhyolite flows and domes. Some of the stratified tuff was also reworked by water.

Two types of vitrophyre are present in the rhyolite of Keg Mountain. 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, 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 that resemble fiamme. Fused tuff has a glassy texture and strongly resembles ash-flow tuff.

From compositional trends, Plavidal (1987) concluded that the rhyolite of Keg Mountain is compositionally gradational into the overlying Topaz Mountain Rhyolite, and represents a more mafic magma from which the Topaz Mountain Rhyolite evolved.

Plavidal (1987) reported K-Ar dates of 6.7 ± 0.3 and 6.9 ± 0.3 Ma for vitrophyres (possibly fused tuff and contaminated), and 6.9 ± 0.3 Ma for an ash-flow tuff (probably a fused tuff and contaminated) in the rhyolite of Keg Mountain. Lindsey and others (1975) reported fission-track dates of 9.6 ± 0.9 and 10.3 ± 0.6 Ma for the rhyolite of Keg

Mountain. Morris (1987) reported corrected dates (9.8 and 10.6) and that the samples used came from flow rocks. We are reluctant to assign a date for the rhyolite of Keg Mountain using these data.

Stratified tuff (Tkmt): The stratified tuff member of the rhyolite of Keg Mountain 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 pyroclasts, including abundant pumice clasts, volcanic rock fragments (mostly rhyolite of Keg Mountain flows and lesser stratified tuff), and sparse crystal fragments in an ash matrix. Size sorting also varies. Beds that contain mostly ash with limited lithic and pumice clasts are common, and the clasts are typically much larger than the ash matrix. These poorly sorted beds might be surge deposits. In other beds, volcanic rock fragments and pumice clasts dominate and are roughly the same size. Beds of mostly lapilli-sized (0.08 to 2.5 inch [2 to 64 mm]) and block-sized (2.5 inch [64 mm]) pyroclasts are present; the blocks and larger lapilli are commonly pumice. Though not discriminating between this unit and the stratified tuff in the Topaz Mountain Rhyolite, Lindsey (1979) documented that both units are water-lain and air-fall. Earlier, Lindsey (1975) showed that glass in both units was progressively altered, first to clinoptilolite and then to potassium feldspar, and extensively argillized (montmorillonite), zeolitized, and feldspathically altered throughout Keg Mountain (Lindsey and others, 1974; Lindsey, 1975). Beds of stratified tuff are from 0 to 300 feet (0 to 90 m) thick.

The unit was reportedly emplaced as ash-flow and debris-flow deposits (Plavidal, 1987). Debris-flow deposits reportedly contain abundant boulders of the rhyolite of Keg Mountain in an ash matrix (Plavidal, 1987). Staub (1975) noted that this was a characteristic of the basal rubble zones of Miocene rhyolite flows in the Picture Rock Hills. These rocks might also be tuff breccias. Plavidal (1987) reported the presence of a densely welded ash-flow tuff facies containing large (1.5 inch [3 cm]) phenocrysts of plagioclase. This unit was not identified during our mapping, and may be a "fused tuff" (see above).

Rhyolite flows, domes, and intrusions (Tkm): This unit consists of flows, domes, and shallow intrusions of rhyolite. The rhyolite is gray to dark purple and contains abundant, large (0.4 inch [10 mm]) phenocrysts of plagioclase, and lesser amounts of sanidine, quartz, biotite, and opaque mineral phenocrysts. The matrix is devitrified glass. Black vitrophyre occurs at the base of some flows and domes. Basal rubble-zone breccias are exposed locally and contain clasts of flows and rare stratified tuff. Modal and chemical analyses from Plavidal (1987) show that the unit is mostly rhyolite and quartz-rich rhyolite. The eight analyses in appendices A and B, and figures 3 and 4 were selected as representative of this unit because sample descriptions by Plavidal (1987) imply they are uncontaminated vitrophyres of lava flows. The unit was erupted from multiple, local vents, with individual flows and domes coalescing to form the irregular extent of the unit. The maximum exposed thickness of the flow-dome-intrusion member of the rhyolite of Keg Mountain is 2,000 feet (610 m). Staub (1975) noted that a major erosional unconformity separated Miocene igneous rocks from older igneous rocks.

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. Many previous workers recognized and mapped the Topaz Mountain Rhyolite at Keg Mountain, but did not use a common nomenclature (Erickson, 1963; Shawe, 1972; Staub, 1975; Morris, 1987; Plavidal, 1987; Pampeyan, 1989).

In this report, we follow the lithologic division of Lindsey (1979). However, we do not use the adjective "alkali" because this term has several different meanings. Beds of stratified tuff occur as discontinuous lenses beneath many rhyolite flows and domes, and 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.

As described above for the rhyolite of Keg Mountain, two types of vitrophyre are present in the Topaz Mountain Rhyolite. One type consists of chilled flow rock. The other type consists of "fused tuff" (Christiansen and Lipman, 1966) that resembles welded 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 (flow, 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. Though not discriminating between this unit and the stratified tuff in the rhyolite of Keg Mountain, Lindsey (1975) showed that glass in both units was progressively altered, first to clinoptilolite and then to potassium feldspar, with extensive argillization (montmorillonite), zeolitization, and feldspathic alteration throughout Keg Mountain (Lindsey and others, 1974; Lindsey, 1975). Beds of Topaz Mountain stratified tuff are from 0 to 280 feet (0 to 85 m) thick.

The unit was deposited as air-fall, ash-flow, and ground-surge eruptions at Spor Mountain (Bikun, 1980). At Keg Mountain and the Picture Rock Hills, the unit was emplaced as (1) water-lain and air-fall deposits (Lindsey, 1979), (2) vent clearing deposits, includes tuff breccias and poorly sorted, ground-surge deposits (this report), and (3) reportedly as ash-flow (Staub, 1975) and debris-flow (Plavidal, 1987) deposits. Plavidal's (1987) description of the debris-flow deposits is characteristic of the basal rubble zones of Topaz Mountain Rhyolite flows in the Picture Rock Hills (Staub, 1975).

Rhyolite flows, domes, and intrusions (Ttm): This unit consists of flows, domes, and dike-like, shallow intrusions of rhyolite. The rhyolite is white, gray, or purple and contains sparse (10 to 15 %), 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. Staub (1975) described basal flow breccias with the same types of clasts. Rare topaz crystals occur in cavities, as do small crystals of hematite, quartz, bixbyite, and pseudobrookite (Staub, 1975). 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 3), and rhyolite (figure 4). The maximum exposed thickness of rhyolite flows and domes is 1,000 feet (300 m).

The Topaz Mountain Rhyolite was dated at 7.8 ± 0.6 and 8.2 ± 0.5 Ma from samples at Keg Mountain (table 1). Lindsey (1982) reported an average age of 6.3 ± 0.1 Ma for five samples of Topaz Mountain Rhyolite from Topaz Mountain. The rhyolite of Keg Mountain, which underlies and is reportedly compositionally gradational into the Topaz Mountain Rhyolite (Plavidal, 1987), was dated at 6.7 ± 0.3 and 6.9 ± 0.3 Ma at Keg Mountain (table 1). We believe the Topaz Mountain Rhyolite at Keg Mountain is closer to 6 rather than 7 million years old, because it overlies the rhyolite of Keg Mountain. Staub (1975) noted that at least two episodes of Topaz Mountain eruptions occurred in the Picture Rock Hills quadrangle.

Flows and domes of rhyolite were probably erupted from several local vents. Staub (1975) noted that a major erosional unconformity separated Miocene igneous rocks from older igneous rocks in the Picture Rock Hills quadrangle. Field relations in the Keg Mtn. Ranch quadrangle indicate the Topaz Mountain Rhyolite was deposited on a paleotopographic surface consisting of gently rolling hills. Shubat and Christenson (1999) stated that in some cases continuous exposures can be followed that show flows at higher elevations becoming dike-like intrusive bodies at lower elevations. Most dike-like bodies and eruptive dome/flow complexes have north-northwest trends (see structure section).

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. A single "stacked unit" (Qaf_2/Qaf_4) is present on the southwest margin of the quadrangle, where thin discontinuous cover of older post-Bonneville alluvial fans (Qaf_2) is being eroded, exposing pre-Lake Bonneville alluvial fans (Qaf_4); the color and pattern on the map indicate the most pervasive unit (Qaf_4).

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

Alluvial-Fan Deposits

Quaternary and Tertiary(?) alluvial-fan deposits (QTaf): The oldest alluvial fans might be early and middle Pleistocene, and, perhaps, as old as Pliocene based on age-related characteristics described by Christenson and Purcell (1985). These fans contain unconsolidated to semi-consolidated, poorly sorted, mostly coarse-grained, clay- to boulder-sized material. The deposits are truncated by and occur above the Bonneville shoreline on the north side of Keg Mountain. They have whalebacks that are as much as 60 feet (18 m) high. This unit is probably present in subsurface beneath Lake Bonneville deposits. The total thickness of this unit is unknown, but exposures and map patterns suggest a maximum thickness of several hundred feet (tens of meters).

Pre-Lake Bonneville alluvial-fan deposits (Qaf_4): Alluvial fans that might be middle and late Pleistocene in age are present above the Bonneville shoreline in piedmont areas on the north, west, and south sides of Keg Mountain in the quadrangle. They are truncated by the shoreline in the adjacent The Hogback (unit Qaf_2 of Oviatt and other, 1994a), Picture Rock Hills (unit Qaf_2 of Shubat, 1999), and Keg Pass (unit Qaf_2 of Shubat and Christenson, 1999) quadrangles. Like the oldest alluvial fans (QTaf), these fans contain poorly sorted, mostly coarse-grained, clay- to boulder-size material. These old fans (Qaf_4) are inactive and undergoing erosion. They are moderately dissected and have broad, relatively flat interfluves 5 to 10 feet (1.5 to 3 m) high. This less-dissected, flat-interfluve, surface morphology distinguishes these fans from the oldest alluvial fans (QTaf). Both fan units are probably present in subsurface beneath Lake Bonneville deposits. The maximum thickness of this unit is unknown, but exceeds interfluve height (10 feet [3 m]).

Lake Bonneville-age alluvial-fan deposits (Qaf_3): A small, fan-shaped deposit of poorly sorted, sand- to boulder-size material occurs along Death Canyon Wash in the northeast corner of the quadrangle. The sediments are mostly reworked lacustrine sand and beach gravel. The surface of the fan is little dissected due to the high porosity. But the fan is incised by younger fans (Qaf_1) and streams at its edges. The Lake Bonneville-age fan (Qaf_3) overlies and is incised into lacustrine deposits above the Provo shoreline, and the toe of the fan is eroded at the Provo shoreline. These relationships indicate that the fan formed after or while the lake fell from the Bonneville level, and while the lake was still at the Provo level. Therefore, the fan may have been deposited during and just after the rapid fall in lake level, and be directly related to the Bonneville flood. The thickness of this fan is estimated to be less than 100 feet (<30 m).

Post-Bonneville alluvial-fan deposits (Qafy): This latest Pleistocene and Holocene unit is mapped on the southeast flank of Keg Mountain where alluvial-fan units Qaf_1 and

Qaf_2 can not be separated. Typically, the older fans (Qaf_2) have slightly dissected surfaces, while the younger fans (Qaf_1) are definitely active and not being eroded. However, gradations exist between undissected and dissected surfaces, and this unit was mapped where fan surfaces are midway between the extremes. Our combined unit is equivalent to mostly Holocene alluvial fans in adjacent quadrangles (units Qaf_1 of Shubat and Christenson, 1999; Shubat, 1999; Oviatt and others, 1994a).

Older post-Bonneville alluvial-fan deposits (Qaf_2): Poorly sorted, sand- to cobble-size material comprises alluvial fans that overlie and are incised into Pleistocene alluvial-fan and Lake Bonneville lacustrine deposits. These fans are probably latest Pleistocene and Holocene in age, and are present on all sides of Keg Mountain. In some areas these deposits contain fine-grained sediments reworked from lacustrine deposits, though overall they are generally coarser-grained than younger alluvial-fan deposits (Qaf_1) The surfaces of these fans (Qaf_2) are inactive and undergoing erosion, but overall dissection is limited. Locally, these fans are overlain or cut by the youngest alluvial-fan deposits (Qaf_1). These older post-Bonneville alluvial-fan deposits are less than 50 feet (15 m) thick.

Younger post-Bonneville alluvial-fan deposits (Qaf_1): Poorly sorted sand and gravel comprise these active alluvial fans, though in many areas these fans contain finer grained sediments reworked from lacustrine deposits. These Holocene fans are most prevalent below the Provo shoreline on the east side of Keg Mountain and the Old River Bed, and overlie and are incised into older alluvial-fan and lacustrine deposits. These fans are distinguished from their older counterparts by their finer grain texture and active surfaces. These youngest alluvial fans locally include and are laterally gradational into stream alluvium (Qal), and mixed alluvium and colluvium (Qac). Deposits are less than 50 feet (15 m) thick.

Stream Alluvium (Qal)

Stream alluvium is present in modern stream channels in upland areas and in the Old River Bed, and is latest Pleistocene and Holocene in age. In upland areas, stream alluvium is unconsolidated, poorly sorted, clay- to boulder-size sediment. In the Old River Bed, it is only fine-grained, calcareous sediment (clay, silt and sand). Stream alluvium is laterally gradational into the youngest alluvial-fan deposits (Qaf_1), and mixed alluvium and colluvium (Qac). Stream alluvium is generally less than 15 feet (<5 m) thick in upland areas, and 20 to 50 feet (6 to 15 m) thick in the Old River Bed, but thicknesses are highly variable. From drillers' logs (Mower and Feltis, 1964), about 70 to 110 feet (21 to 34 m) of alluvial and lacustrine clay, and possibly silt, are present in sub-surface in the Old River Bed.

Alluvium and Colluvium (Qac)

These undivided, late and possibly middle Pleistocene to Holocene deposits were mapped in upland valleys and next to drainages, where fan and stream alluvium, and colluvium could not be separated. Contacts between alluvium and colluvium were not mappable because deposit types are intermixed, deposit origin is uncertain, or separate exposures are too small to show at map scale. This unit consists of locally derived, clay- to boulder-size material. Clasts are commonly angular or sub-angular due to minimal transport. Deposits are less than approximately 30 feet (9 m) thick.

Undivided Lacustrine and Alluvial Deposits (Qla)

Undivided lacustrine and alluvial deposits are located below the Bonneville shoreline, primarily on the north and east sides of Keg Mountain and on the east side of the Old River Bed. This Pleistocene and Holocene unit consists of locally derived clay- to boulder-sized material. The deposits consist of (1) partially reworked pre-Lake-Bonneville fan alluvium (redeposited more or less in place in Lake Bonneville) that lacks the distinct morphology of alluvial fans or of lacustrine deposits (beaches, bars), but can be etched by shorelines; (2) Lake Bonneville deposits that were partially reworked by post-lake alluvial processes and lack lacustrine, stream, or fan morphology; and (3) areas where contacts between lacustrine and alluvial deposits were not mappable. Contacts were not mappable where deposit types are thin, intermixed, and grade laterally and vertically into each other; deposit origin is uncertain; or separate exposures are too small to show at map scale. Therefore lacustrine marl (Qlm) and gravel (Qlg), alluvium and colluvium (Qac), fan (QTaf, Qaf_4, Qaf_2, Qaf_1) and stream alluvium (Qal), and eolian sediments (not mapped) occur locally in this undivided unit. The best example of reworked fan alluvium is on the north side of Keg Mountain, where the surface of the oldest alluvial fans (QTaf) was reworked below the Bonneville shoreline. The thickness of undivided lacustrine and alluvial deposits is unknown, but probably is less than 10 feet (<3 m) in most settings.

Lacustrine Deposits

Lacustrine gravel (Qlg): This unit consists of well-sorted gravel and sandy gravel deposited in Lake Bonneville as barriers, spits, and beaches. The gravel is composed of rounded clasts that were derived mostly from local bedrock or clasts in pre-Lake Bonneville alluvium. Gravel deposits are preserved from below the Bonneville shoreline to just below the Provo shoreline on the east side of Keg Mountain, at the "Snow Plow," and in the northwest corner of the quadrangle. The "Snow Plow," which is located in the northeast corner of the quadrangle and is an impressive example of a series of stacked, transgressive-phase V-bars, or cuspate barrier bars first noted by Gilbert (1890). The "Snow Plow" probably formed from currents that were converging from the north and south. The thickness of the gravel deposits is variable, but generally is less than 20 feet (<6 m). Locally the thickness may exceed 50 feet (15 m)(Oviatt and others, 1994a).

Lacustrine marl (Qlm): Lacustrine marl as defined by Oviatt (1987) is basically the white marl of Gilbert (1890). It is best preserved below the Provo shoreline on the east side of Keg Mountain and the Old River Bed. It is composed of very thinly bedded to indistinctly laminated, fine-grained, white to gray calcium carbonate and minor detrital sediment that were deposited in deep or quiet waters of Lake Bonneville. Abundant ostracodes are found throughout the unit. Gastropods are locally abundant near, and detritus-rich marl is present at, the base and top of the unit.

Pahvant Butte basaltic ash, approximately 15,500 years old (Oviatt and Nash, 1989), occurs locally near the top of the unit and is rarely more than 0.1 inch (1 mm) thick. The marl varies in thickness from 6 to 30 feet (2 to 10 m)(Oviatt and others, 1994a).

At a site south of Keg Mountain Ranch (roughly center NE1/4 section 8, T. 12 S., R. 8 W.; PB on plate 1), the Pahvant Butte ash is about 0.8 inches (2 cm) below the Bonneville flood contact (or bed). Nearby (roughly center E1/2 section 8, T. 12 S., R. 8 W., BFC on plate 1), this contact separates lacustrine marl from overlying lacustrine carbonate sand (Oviatt and others, 1994a). The Bonneville flood bed typically consists of laminated sandy or ostracode-rich marl, with an abrupt lower boundary and is interpreted as being deposited during the rapid drop in Lake Bonneville from the Bonneville to the Provo level (Oviatt and others, 1994b).

Lacustrine gravelly sand (Qls): This unit varies from well-sorted to very poorly sorted, fine- to very coarse-grained sand, and is typically pebbly and silty. It is only present in the northeast corner of the quadrangle. These sediments were probably deposited offshore after nearshore wave action in Lake Bonneville winnowed this sand and silt from alluvial fans. The deposits are presently undergoing erosion; they are dissected by stream beds, and the surfaces are being modified by wind. This unit is less than 20 feet (<6 m) thick.

Lacustrine carbonate sand (Qlk): This calcareous sand stratigraphically overlies the lacustrine marl, and is found exclusively below the Provo shoreline on the east side of Keg Mountain. The unit consists of fine- to medium-grained sand with coarse sand- to granule-sized clasts, carbonate pellets, and carbonate-coated gastropods. Oviatt (1989) hypothesized that the carbonate-rich sediments were deposited during the Provo stage. This unit, which is locally reworked by alluvial and eolian processes, is less than 15 feet (5 m) thick.

Fine-grained deltaic deposits (Qdf): This unit contains laminated to very thick-bedded, calcareous clay, silt, and fine sand. It is only exposed along the north-central margin of the quadrangle on the west side of the Old River Bed. Just north of the quadrangle, this unit forms low mounds above the surrounding younger (post-Lake Bonneville) alluvial fans (Qaf_1). These mounds show the unit is 0 to at least 10 feet (0 to 3 m) thick.

The unit was deposited in the under-flow fan during the overflow of the fresh-water lake in the Sevier Desert basin into Lake Bonneville prior to the Stansbury oscillation during the early transgressive phase of Lake Bonneville (Oviatt and others, 1994a). This unit is the lower yellow clay of Oviatt (1987) and yellow clay of Gilbert (1890), and is latest Pleistocene in age.

STRUCTURE

Because the distinction between a caldera and a cauldron may be unclear to many readers, we will define the terms. Elston (1978) defined them as follows. 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, we use the two terms as follows. 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.

Keg Cauldron

Shubat and Snee (1992) and Shubat and Christenson (1999) proposed the name Keg cauldron for the volcanic subsidence feature that was the source of the Keg Tuff. Because the Keg Tuff has only been recognized at Keg Mountain, they suggested that it is a locally derived unit. They proposed that the tuff was erupted from a cauldron centered on a granodiorite porphyry stock located in the south-central part of the Keg Pass quadrangle (Shubat and Christenson, 1999)(figure 5). As defined by Shubat and Christenson (1999), the location of and the ash-flow erupted from the Keg cauldron differs from the "Keg caldera" postulated by Shawe (1972). Shawe's (1972) "Keg caldera" margin is geophysically reasonable, roughly around a gravity low on the southeast flank of the gravity ridge, north and east of the Keg cauldron (figure 5).

The boundaries of the cauldron are not known, but Shubat and Christenson (1999) speculated that the cauldron approximately coincides with the outcrop distribution of the Keg Tuff. Strikes and dips measured on layering in the Keg Tuff outline a broad, low-relief dome with the granodiorite porphyry stock at its center. Because the Keg Tuff and the granodiorite porphyry have similar compositions and ages, Shubat and Christenson (1999) considered the granodiorite porphyry to be comagmatic with the Keg Tuff and considered it to be a resurgent intrusion that caused doming.

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 edges of the caldera were well defined by Lindsey (1982) and Shawe (1972), but the locations of the northern and eastern edges remained ill defined.

Shubat and Christenson (1999), and Shubat (1999) placed the eastern edge of the Thomas caldera along the western margin of Keg Mountain (figure 5) for geologic and geophysical reasons, much as Shawe (1972) and Lindsey (1982) did. Examinations in the Keg Pass (Shubat and Christenson, 1999) and Picture Rock Hills (Shubat, 1999) quadrangles, and for this report revealed no stratigraphic or structural evidence for the Thomas caldera passing through or east of Keg Mountain. Mt. Laird Tuff exposures are thin in the Keg Mtn. Ranch quadrangle (<240 feet [73 m]), so the unit appears to be mostly outflow from a caldera. 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 5; Shubat, 1999).

Dugway Valley Cauldron

Lindsey (1982) identified and named the Dugway Valley cauldron (figure 5), 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). The southwestern margin of the cauldron was well defined by Lindsey (1982) and the southeastern margin was defined by Shubat (1999). The locations of the remaining margins of this cauldron, however, remain ill defined. In the Picture Rock Hills and Keg Pass quadrangles, 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 (Shubat and Christenson, 1999), 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 5). Evidence for the existence of the cauldron consists of two geophysical observations: (1) an oval-shaped gravity low (figure 5) 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 (Shubat and Christenson, 1999), Keg Mtn. Ranch, and Picture Rock Hills (Shubat, 1999) quadrangles fall into several north- to east-trending zones. All the zones consist of many small dikes and plugs of rhyolite porphyry that are typically elongate north-south to northeast-southwest. Only one fault was mapped within these zones, and it was at a high angle to zone trend, so the control for the rhyolite-porphyry distribution is not known. Only the northeast end of the southern northeast-trending zone is present in the Keg Mtn. Ranch quadrangle (center-west margin of map).

Shubat and Christenson (1999) inferred 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.

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 (Shubat and Christenson, 1999), Keg Mtn. Ranch, and Picture Rock Hills (Shubat, 1999) quadrangles. Dike-like bodies of Topaz Mountain Rhyolite trend about north-northwest, and isolated domes in the Keg Pass quadrangle are aligned in the same direction. Coalesced flows and domes form ridges and exposures of Topaz Mountain Rhyolite that also trend north-northwest. No mapped faults appear to coincide with the lineaments, but several faults at Keg Mountain have this trend.

Shubat and Christenson (1999) interpreted 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 (about 6 to 20 million years ago).

High-Angle Faults

At least three periods of high-angle faulting occurred in Keg Mountain and the Picture Rock Hills (Shubat and Christenson, 1999; Shubat, 1999; this report). Older faults offset the Eocene and Oligocene Keg, Mt. Laird, and Joy Tuffs (roughly 37, 36 and 35 million years old, respectively); some are occupied by Eocene and Oligocene intrusions while others are covered by late Miocene flows. Younger faults cut the late Miocene rhyolite of Keg Mountain and Topaz Mountain Rhyolite (6 to 10 million years old). Fault scarps are not present in Quaternary units in the Keg Mtn. Ranch quadrangle, but such faults are exposed in the Picture Rock Hills quadrangle (Shubat, 1999) and east of the Old River Bed just east of the Keg Mtn. Ranch quadrangle (Oviatt and others, 1994a).

An older arcuate fault, with steep dip and small stratigraphic separation (less than 100 feet [<30 m]), appears to trend north-south and northwest-southeast on the west-central edge of the Keg Mtn. Ranch quadrangle (SW1/4 section 4, T. 12 S., R. 9 W.). The fault juxtaposes the Keg (Tk) and Mt. Laird (Tml) Tuffs, and Mt. Laird Tuff and andesite of Keg Pass (Ta). A rhyolite porphyry plug (Trp) appears to have intruded the fault. These relationships indicate that the fault moved after 36.54 ± 0.06 Ma and before 35.14 ± 0.06 Ma (table 1).

Two northeast-trending faults on the west-central edge of the Keg Mtn. Ranch quadrangle cut the Mt. Laird Tuff. Field relationships do not constrain the age of faulting; it could even be post Miocene. Several air-photo lineaments with roughly the same trend cross the Mt. Laird Tuff in the same area and might be similar high-angle faults.

In the Thomas Range, Lindsey (1982) determined that high-angle faults largely postdated the 21-million-year-old Spor Mountain Formation. 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 the northeast-trending faults in the Keg Mtn. Ranch quadrangle.

We mapped three younger high-angle faults in the Keg Mtn. Ranch quadrangle that cut Topaz Mountain Rhyolite. These faults strike northwest, and have steep dips and small stratigraphic separations (less than 100 feet [<30 m]).

ECONOMIC RESOURCES

Metallic Minerals

Mineral exploration at Keg Mountain since 1978 was spurred by Morris' (1978) report of unprospected pyritized rock in the Keg Pass quadrangle, and resulted in discoveries of lead-, silver-, copper- and gold-bearing mineralization at other sites (figure 2; Shubat, 1987). Zimbelman and others (1991) provided some analytical data for metals in rock samples from Keg Mountain.

Metallic mineral exploration in the quadrangle was conducted in the western part of section 33, T. 11 S., R. 9 W. (figure 2). Three shallow drill holes in this area yielded cuttings that contained slightly anomalous values of gold. The highest value obtained was 0.049 ppm Au and most values were below detection limits (Robert Steele, written communication, 1989). The holes penetrated altered rock mapped as Mt. Laird Tuff, possibly near hypabyssal intrusions in a vent(?) for Mt. Laird flows. One hole was drilled near a small pebble dike. Alteration consists of locally intense argillization and pyritization.

Industrial Minerals and Rock

Sand and Gravel

Abundant sand and gravel are present in the quadrangle in lacustrine gravel and sand (map units Qlg and Qls) deposited near the shore of Lake Bonneville as beaches, bars, and barriers. The sand and gravel is moderately well size sorted.

Cement Rock

The Howell Limestone and the Pioche Formation may be present beneath the volcanic rocks in the northwest part of the quadrangle and are exposed in the Keg Pass and Table Mountain quadrangles. Silty limestone in the Howell Limestone may have desirable concentrations of calcium carbonate, alumina, and iron for cement. The Pioche Formation could be a source of alumina and silica for cement.

High-Calcium Limestone

Some limestone units, possibly present beneath volcanic rocks in the northwest part of the quadrangle, 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 Dome Formation (Tripp, 1991). The Dome Formation may be present in the undifferentiated Cambrian carbonate rock map unit (€l).

Zeolites

Significant zeolite mineralization (Lindsey, 1975) exists in the stratified tuff member of the Topaz Mountain Rhyolite (Ttmt) and the stratified tuff member of the rhyolite of Keg Mountain (Tkmt). Clinoptilolite makes up 60 to 90 percent of the tuffs, and is the only zeolite mineral identified in them (Lindsey and others, 1974). Mayes and Tripp (1991) summarized the available information on the mineralization. Lindsey (1975) showed that alteration of the tuffs produced feldspathic as well as zeolitic mineral assemblages. The feldspathic assemblage contains potassium feldspar as the dominant mineral. Lindsey (1975) concluded that the alteration was caused by percolating groundwater 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) and some volcanic rocks in the quadrangle could be used for crushed stone.

The Joy Tuff (Tj) and rhyolite flows, domes and intrusions in the Topaz Mountain Rhyolite (Ttm) could be used for crushed stone. Crushed devitrified rhyolite (Ttm) could be used for road base material, bituminous aggregate, or possibly cement aggregate.

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 uses.

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. 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). These materials might also be present in the rhyolite of Keg Mountain (Tkm, Tkmt). None of the vitrophyres observed were perlitic.

Uranium Prospect?

A possible uranium prospect occurs in the stratified tuff member of the rhyolite of Keg Mountain (Tkmt) on the east side of Keg Mountain (center section 6, T. 12 S., R. 8 W.). Workings consists of a short (20 ft [6 m]) decline and several bulldozer cuts. The name of the site is the JB prospect and 0.03 percent equivalent U_3O_8 was reported (Utah Mineral Occurrence System [UMOS] files at the Utah Geological Survey). Weak argillic alteration is present in the tuff. See Zielinski and others (1980) on uranium mineralization in stratified tuffs (Tkmt, Ttmt) at Keg Mountain.

WATER RESOURCES

No perennial streams flow in the quadrangle. Discharge from the lone spring in the quadrangle (Willow Spring;

NW1/4 NW1/4 NW1/4 section 2, T. 12 S., R. 9 W.) has been diverted to a storage tank for livestock watering. Waddell (1967, figure 6, table 1) reported 998 parts/million (~mg/l) evaporated total dissolved solids and other analytical results for Willow Spring, but plotted the spring about a mile (1.6 km) to the northeast of its true location. The quadrangle straddles the divide between the Sevier Desert basin (Mower and Feltis, 1968) and the Great Salt Lake Desert basin (Gates and Kruer, 1981).

Seven water wells are shown in the eastern part of the quadrangle on the topographic map, six are in the Old River Bed and the other is on an alluvial fan above the Old River Bed. Mower and Feltis (1964, 1968) showed five wells in the quadrangle; all are in the Old River Bed, some are near the wells shown on the topographic map while others are not. Chemical and thermal data are only available for one water well in the quadrangle (Mower and Feltis, 1964), probably that shown on the topographic map just south of the west half of the section 4-9 line, T. 12 S., R. 8 W. This water was of the bicarbonate-chloride type, contained 530 parts/million (~mg/l) total dissolved solids, and had a temperature of 64°F (20°C) (Mower and Feltis, 1964). Water levels in the Old River Bed are about 20 to 60 feet (6 to 18 m) below the ground surface (Mower and Feltis, 1964). Regionally, Bedinger and others (1984) showed that the elevation of the ground-water table decreases from southeast to northwest along the Old River Bed, from about 4,600 feet (1,400 m) southeast of the quadrangle to 4,400 feet (1,340 m) north of the quadrangle.

GEOLOGIC HAZARDS

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

One earthquake, smaller than magnitude 4, occurred between 1975 and 1989 in the southeast part of the quadrangle (Goter, 1990). The nearest faults with evidence for surface rupture in post-Bonneville time (<13,000 years ago) are just east of the quadrangle on the east side of the Old River Bed (Oviatt and others, 1994a) and between the Picture Rock Hills and Crater Bench (Shubat, 1999; Oviatt and others, 1994a). 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) in an area of moderate earthquake hazard.

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

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

Soil 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 active alluvial fans (Qaf1, Qafy) at mountain fronts, and that expansive, soluble, and erodible materials are present in fine-grained lake sediments (Qlm, Qdf) along the eastern side of the quadrangle.

Ground water is deeper than 10 feet along the Old River Bed (about 20 to 60 feet deep)(Mower and Feltis, 1964), but still might be a problem in construction (Hecker and Harty, 1988).

The volcanic rocks of Keg Mountain are uranium-rich (Shubat, 1999; Zielinski and others, 1980) and do produce some radon gas. 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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REFERENCES CITED

Baedecker, P.A., editor, 1987, Methods of geochemical analysis: U.S. Geological Survey Bulletin 1770, 132 p.

Bankey, Viki, and Cook, K.L., 1989, Complete Bouguer gravity map and related geophysical maps of the Delta 1° x 2° quadrangle, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-2081-A, scale 1:250,000.

Bedinger, M.S., Mason, J.L., Langer, W.H., Gates, J.S., Stark, J.R., and Mulvihill, D.A., 1984, Maps showing ground-water levels, springs, and depth to ground water, Basin and Range province, Utah: U.S. Geological Survey Water Resources Investigations Report WRI 83-4122-B, 12 p., scale 1:500,000.

Best, M.G., 1982, Igneous and metamorphic petrology: New York, W.H. Freeman and Company, 630 p.

Best, M.G., 1988, Early Miocene changes in direction of least principal stress, southwestern United States--Conflicting inferences from dikes and metamorphic core-detachment fault terranes: Tectonics, v. 7, no. 2, p. 249-259.

Bikun, J.V., 1980, Fluorine and lithophile element mineralization at Spor Mountain, Utah: Tempe, Arizona State University, M.S. thesis, 195 p.

Black, B.D., 1993, The radon-hazard-potential map of Utah: Utah Geological Survey Map 149, 12 p., scale 1:1,000,000.

Campbell, D.L., and Visnyei, Andrew, 1989, Audio-magnetotelluric soundings in the Delta Utah 1° x 2° quadrangle: U.S. Geological Survey Open-File Report 89-538, 71 p.

Christenson, G.E., and Purcell, Charles, 1985, Correlation and age of Quaternary alluvial-fan sequences, Basin and Range province, southwestern United States, *in* Weide, D.L., editor, Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 115-122.

Christiansen, R.L., and Lipman, P.W., 1966, Emplacement and thermal history of a rhyolite lava flow near Fortymile Canyon, southern Nevada: Geological Society of America Bulletin, v. 77, p. 671-684.

Currey, D.R., 1980, Coastal geomorphology of Great Salt Lake and vicinity, *in* Gwynn, J.W., editor, Great Salt Lake: A scientific, historical, and economic overview: Utah Geological and Mineral Survey Bulletin 116, p. 69-82.

Currey, D.R., 1982, Lake Bonneville--selected features of relevance to neotectonic analysis: U.S. Geological Survey Open-File Report 82-1070, 30 p.

Currey, D.R., Atwood, Genevieve, and Mabey, D.R., 1984, Major levels of Great Salt Lake and Lake Bonneville: Utah Geological and Mineral Survey Map 73, scale 1:750,000.

Currey, D.R., Oviatt, C.G., and Plyler, G.B., 1983, Lake Bonneville stratigraphy, geomorphology, and isostatic deformation in west-central Utah: Utah Geological and Mineral Survey Special Study 62, p. 63-82.

Elston, W.E., 1978, Mid-Tertiary cauldrons and their relationship to mineral resources, southwestern New Mexico, *in* Chapin, C.E., and Elston, W.E., editors, Field guide to selected cauldrons and mining districts of the Datil-Mogollon volcanic field, New Mexico: New Mexico Geological Society Special Publication no. 7, p. 107-113.

Erickson, M.P., 1963, Volcanic geology of western Juab County, Utah, *in* Sharp, B.J., and Williams, N.C., editors, Beryllium and uranium mineralization in western Juab County, Utah: Utah Geological Society, Guidebook to the Geology of Utah no. 17, p. 23-35.

Fisher, R.V., and Schmincke, H.-U., 1984, Pyroclastic rocks: Berlin, Springer-Verlag, 472 p.

Gates, J.S., and Kruer, S.A., 1981, Hydrologic reconnaissance of the southern Great Salt Lake Desert and summary of the hydrology of west-central Utah: Utah Department of Natural Resources Technical Publication 71, 55 p.

Gilbert, G.K., 1890, Lake Bonneville: U.S. Geological Survey Monograph 1, 438 p.

Goter, S.K., compiler, 1990, Earthquakes in Utah--1984-1989: U.S. Geological Survey map, scale 1:500,000.

Gutscher, M.A., 1989, Paleomagnetism of Oligocene volcanics in the East Tintic Mountains, Utah: Burlington, Vermont, University of Vermont, M.S. thesis, 240 p.

Hecker, Suzanne, and Harty, K.M., compilers, 1988, Shallow ground water and related hazards in Utah: Utah Geological and Mineral Survey Map 110, 19 p., scale 1:750,000.

Hintze, L.F., 1993, Geologic history of Utah: Brigham Young University Geology Studies, Special Publication 7, 202 p.

Hintze, L.F., and Robison, R.A., 1975, Middle Cambrian stratigraphy of the House, Wah Wah, and adjacent ranges in western Utah: Geological Society of America Bulletin, v. 86, p. 881-891.

International Conference of Building Officials, 1991, Uniform building code: International Conference of Building Officials, Whittier, California, 1050 p.

Kucks, R.P., 1991, Aeromagnetic anomaly map and related geophysical maps of the Delta 1° x 2° quadrangle, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-2081-B.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, Albert, and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, pt. 3, p. 745-750.

Lindsey, D.A., 1975, The effect of sedimentation and diagenesis on trace element composition of water-laid tuff in the Keg Mountain area, Utah: U.S. Geological Survey, Prefessional Paper 818-C, 35p.

—1977, Epithermal beryllium deposits in water-laid tuff, western Utah: Economic Geology, v. 72, no. 2, p. 219-232.

—1979, Geologic map and cross sections of Tertiary rocks in the Thomas Range and northern Drum Mountains, Juab County, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1176, scale 1:62,500.

—1982, Tertiary volcanic rocks and uranium in the Thomas Range and northern Drum Mountains, Juab County, Utah: U.S. Geological Survey Professional Paper 1221, 71 p.

Lindsey, D.A., Buzzard, K.A., Conklin, N.W., and Lee, L.M., 1974, Mineralogical and trace element data for water-laid tuff at Keg Mountain, Juab County, Utah: U.S. Geological Survey report USGS-GD-74-012, available from National Technical Information Service (NTIS) as report PB-231 925/AS, 32 p.

Lindsey, D.A., Naeser, C.W., and Shawe, D.R., 1975, Age of volcanism, intrusion, and mineralization in the Thomas Range, Keg Mountain, and Desert Mountain, western Utah: U.S. Geological Survey Journal of Research, v. 3, no. 5, p. 597-604.

Mayes, B.H., and Tripp, B.T., 1991, Zeolite minerals in Utah: Utah Geological Survey Open-File Report 210, 170 p.

Morris, H.T., 1978, Unprospected zone of pyritic alteration in west-central Utah: U.S. Geological Survey Open-File Report 78-791, 8 p.

—1987, Generalized geologic map of the Delta 2° quadrangle, Tooele, Juab, Millard, and Utah Counties, Utah: U.S. Geological Survey Open-File Report 87-185, scale 1:250,000.

Mower, R.W., and Feltis, R.D., 1964, Ground-water data, Sevier Desert, Utah: Utah Department of Natural Resources, State Engineer (Division of Water Rights) Basic-Data Report no. 9, 34 p., prepared by U.S. Geological Survey.

—1968, Ground-water hydrology of the Sevier Desert, Utah: U.S. Geological Survey Water Supply Paper 1854, 75 p., 7 plates.

Nutt, C.J., Thorman, C.H., Zimbelman, D.R., and Gloyn, R.W., 1991, Geologic setting and trace-element geochemistry of the Detroit mining district and Drum gold mine, Drum Mountains, west-central Utah, *in* Raines, G.L., Lisle, R.E., Schafer, R.W., and Wilkinson, W.H., editors, Geology and ore deposits of the Great Basin, Symposium Proceedings: Reno, Geological Society of Nevada, p. 491-509.

Oviatt, C.G., 1984, Lake Bonneville stratigraphy at the Old River Bed and Leamington, Utah: Salt Lake City, University of Utah, Ph.D. dissertation, 122 p.

—1987, Lake Bonneville stratigraphy at the Old River Bed, Utah: American Journal of Science, v. 287, p. 383-398.

—1989, Quaternary geology of part of the Sevier Desert, Millard County, Utah: Utah Geological and Mineral Survey Special

Study 70, 41 p.

Oviatt, C.G., Currey, D.R., and Sack, Dorothy, 1992, Radiocarbon chronology of Lake Bonneville, eastern Great Basin, USA: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 99, p. 225-241.

Oviatt, C.G., and Nash, W.P., 1989, Late Pleistocene basaltic ash and volcanic eruptions in the Bonneville basin, Utah: Geological Society of America Bulletin, v. 101, p. 292-303.

Oviatt, C.G., Habinger, G.D., and Hey, J.E., 1994b, Variation in the composition of Lake Bonneville marl -- a potential key to lake-level fluctuations and paleoclimate: Journal of Paleolimnology, v. 11, p. 19-30.

Oviatt, C.G., Sack, Dorothy, and Felger, T.J., 1994a, Quaternary geologic map of the Old River Bed [northern Sevier Desert], Millard, Juab and Tooele Counties, Utah: Utah Geological Survey Map 169, 24 p., scale 1:62,500.

Pampeyan, E.H., compiler, 1989, Geologic map of the Lynndyl 30- by 60-minute quadrangle, west-central Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1830, 9 p., scale 1:100,000.

Plavidal, K.R., 1987, The geology [geochemistry] and petrology of the eastern Keg Mountains, Juab County, Utah: Salt Lake City, University of Utah, M.S. thesis, 137 p.

Ren, Xiaofen, Kowallis, B.J., and Best, M.G., 1989, Paleostress history of the Basin and Range province in western Utah and eastern Nevada from healed microfracture orientations in granites: Geology, v. 17, p. 487-490.

Shawe, D.R., 1972, Reconnaissance geology and mineral potential of the Thomas, Keg, and Desert calderas, central Juab County, Utah: U.S. Geological Survey Professional Paper 800-B, p. B67-B77.

Shawe, D.R., and Stewart, J.H., 1976, Ore deposits as related to tectonics and magmatism, Nevada and Utah: American Institute of Mining, Metallurgical and Petroleum Engineers, Transactions, v. 260, p. 225-232 [presented at Annual Meeting, Las Vegas, Nevada, 1977].

Shubat, M.A., 1987, Geology and mineral occurrences of northern Keg Mountain, Juab County, Utah, *in* Kopp, R.S. and Cohenour, R.E., editors, Cenozoic geology of western Utah: Utah Geological Association Publication 16, p. 451-462.

Shubat, M.A., 1999, Geologic map of the Picture Rock Hills quadrangle, Juab County, Utah: Utah Geological Survey Miscellaneous Publication 99-3, 22 p., scale 1:24,000.

Shubat, M.A., and Christenson, G.E., 1999, Geologic map of the Keg Pass quadrangle, Juab County, Utah: Utah Geological Survey Miscellaneous Publication 99-4, 28 p., scale 1:24,000.

Shubat, M.A., and Snee, L.W., 1992, High-precision $^{40}Ar/^{39}Ar$ geochronology, volcanic stratigraphy, and mineral deposits of Keg Mountain, west-central Utah, *in* Thorman, C.H., editor, Applications of structural geology to mineral and energy resources of the central and western United States: U.S. Geological Survey Bulletin 2012, p. G1-G16.

Solomon, B.J., 1992, Geology and the indoor-radon hazard in southwestern Utah, *in* Harty, K.M., editor, Engineering and environmental geology of southwestern Utah: Utah Geological Association Publication 21, p. 165-172.

Staatz, M.H, and Carr, W.J., 1964, Geology and mineral deposits of the Thomas and Dugway Ranges, Juab and Tooele Counties, Utah: U.S. Geological Survey Professional Paper 415, 188 p.

Staub, A.M., 1975, Geology of the Picture Rock Hills quadrangle, Juab County, Utah: Salt Lake City, University of Utah, M.S. thesis, 87 p.

Stewart, J.H., Moore, W.J., and Zietz, Isidore, 1977, East-west patterns of Cenozoic igneous rocks, aeromagnetic anomalies, and mineral deposits, Nevada and Utah: Geological Society of America Bulletin, v. 88, no. 1, p. 67-77.

Streckeisen, Albert, 1976, To each plutonic rock its proper name: Earth Science Reviews, v. 12, p. 1-33.

Streckeisen, Albert, 1978, Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites, and melitic rocks: Neues Jahrbuch fuhr Mineralogie Abhandlungen, Band (v.) 134, p. 1-14.

Tripp, B.T. 1991, The industrial rock and mineral industry in Utah, 1990: Utah Geological Survey Circular 82, 31 p.

Varnes, D.J., and Van Horn, Richard, 1961, Reinterpretation of two of G.K. Gilbert's Lake Bonneville sections, Utah: U.S. Geological Survey Professional Paper 424-C, Geological Survey Research 1961, p. C98-C99.

Waddell, K.M., 1967, Reconnaissance of the chemical quality of water in western Utah, part 1, Sink Valley area, drainage basins of Skull, Rush, and Government Creek valleys, and the Dugway Valley - Old River Bed area: Utah Geological and Mineralogical Survey Water-Resources Bulletin 9, 15 p., 2 oversize tables.

Zielinski, R.A., Lindsey, D.A., and Rosholt, J.N., Jr., 1980, The distribution and mobility of uranium in glassy and zeolitized tuff, Keg Mountain area, Utah, U.S.A.: Chemical Geology, v. 29, no. 1, p. 139-162.

Zimbelman, D.R., Arbogast, B.F., Hageman, Phil, Hill, R.H., Fey, D.L., and Bullock, J.H., Jr., 1991, Analytical results and sample locality maps for rock samples collected in and near the Delta 1° x 2° quadrangle, Tooele, Juab, Millard and Utah Counties, Utah: U.S. Geological Survey Open-File Report 91-114, 256 p., 7 plates.

Zoback, M.L., Anderson, R.E., and Thompson, G.A., 1981, Cainozoic evolution of the state of stress and style of tectonism of the Basin and Range province of the western United States: Royal Society of London Philosophical Transactions series A, v. 300, p. 407-434.

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 (Shubat and Christensen, 1999). 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

***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-21-8	Tml	767	69.36	19.43	0.13	0.00	2.48	2.61	4.17	1.69	n	y	0.00
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

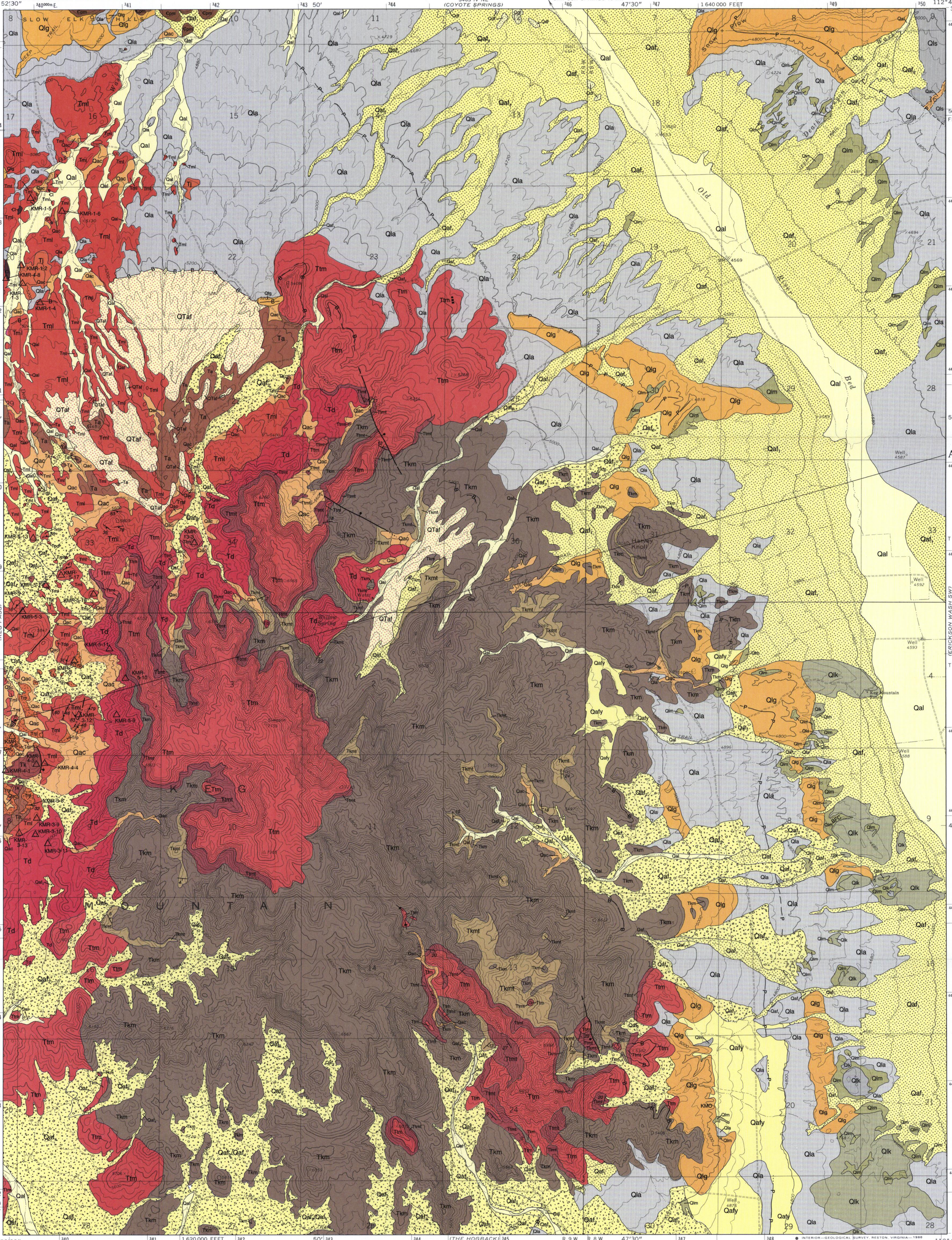
Table 1 (continued)

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



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

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

14.1°
251 MILS

1999 MAGNETIC DECLINATION AT CENTER OF SHEET

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 MTN. RANCH QUADRANGLE, JUAB COUNTY, UTAH

by

Michael A. Shubat, Tracey J. Felger and Jon K. King

1999

DESCRIPTION OF GEOLOGIC UNITS

Qal Stream alluvium (Holocene and latest Pleistocene) - Unconsolidated, poorly sorted clay, silt, sand, and gravel, to boulder size, in modern stream channels in upland areas, and calcareous clay, silt, and sand in the Old River Bed; generally less than 15 feet (<5 m) thick in upland areas and 20 to 50 feet (6 to 15 m) thick in Old River Bed.

Qafy Post-Bonneville alluvial-fan deposits (Holocene and latest Pleistocene) - Mapped where unit Qaf_1 cannot be separated from Qaf_2 on southeast flank of Keg Mountain; equivalent to mostly Holocene alluvial fans in adjacent quadrangles (units Qaf_1 of Shubat and Christenson, 1999; Shubat, 1999; Oviatt and others, 1994a); less than 50 feet (15 m) thick.

Qaf_1 Younger post-Bonneville alluvial-fan deposits (Holocene) - Poorly sorted, clay, silt, sand, and gravel in active fans; many only contain fine-grained, reworked lacustrine sediments; locally include and are gradational into stream alluvium (Qal); less than 50 feet (15 m) thick.

Qaf_2 Older Post-Bonneville alluvial-fan deposits (Holocene and latest Pleistocene) - Poorly sorted silt, sand, and gravel, to cobble size, in fans that are inactive and undergoing erosion; some contain finer grained, reworked lacustrine sediments; less than 50 feet (15 m) thick.

Qaf_3 Lake Bonneville-age alluvial-fan deposits (latest Pleistocene) - Poorly sorted sand and gravel, to boulder size, in a fan-shaped deposit that overlies and is incised into lacustrine deposits above the Provo shoreline in the northeast corner of the quadrangle; fan toe is truncated by the Provo shoreline; estimated thickness less than 100 feet (30 m).

Qdf Fine-grained deltaic deposits (latest Pleistocene) - Laminated to very thick-bedded, calcareous clay, silt, and fine sand; only exposed on the north margin of the map; part of the latest Pleistocene delta (underflow fan) of the overflow from the lake in the Sevier Desert basin into Lake Bonneville; up to at least 10 feet (3 m) thick.

Qls Lacustrine gravelly sand (latest Pleistocene) - Well-sorted to very poorly sorted sand and pebbly sand; presently being modified by alluvial and eolian activity; thickness variable but less than 20 feet (6 m).

Qlk Lacustrine carbonate sand (latest Pleistocene) - Fine- to medium-grained, calcareous sand with rounded, coarse sand- to granule-sized clasts, carbonate pellets, and carbonate-coated gastropods; locally reworked by alluvial and eolian activity; less than 15 feet (5 m) thick.

Qlm Lacustrine marl (latest Pleistocene) - White to gray, very thin-bedded to indistinctly laminated, fine-grained, highly calcareous sediment containing abundant ostracodes; locally contains abundant gastropods and clastic-rich marl at the base and top of the unit; Pahvant Butte ash (15,500 years old) locally present near the top of the unit; 6 to 30 feet (2 to 10 m) thick.

Qlg Lacustrine gravel (latest Pleistocene) - Well-sorted sandy gravel and gravel, mostly composed of locally derived, rounded clasts of bedrock and pre-Lake Bonneville alluvial fans; deposited as bars, spits and beaches; thickness variable, but generally less than 20 feet (6 m).

Qac Alluvium and colluvium (Holocene and latest, and possibly middle, Pleistocene) - Locally derived, angular to sub-angular, clay, silt, sand, and gravel, to boulder size, in fan and stream alluvium, and in colluvium in upland valleys and next to drainages; less than about 30 feet (9 m) thick.

Qla Undivided lacustrine and alluvial deposits (Holocene and late, and possibly middle, Pleistocene) - Clay- to boulder-sized deposits that consist of pre-Lake Bonneville alluvial fans partially reworked in the lake, more or less in place; Lake Bonneville deposits partially reworked by post-Bonneville alluvial activity; and areas where contacts between thin lacustrine and alluvial deposits could not be mapped; probably less than 10 feet (3 m) thick.

Qaf_4 Pre-Lake Bonneville alluvial-fan deposits (middle[?] and late Pleistocene) - Poorly sorted, mostly coarse-grained, clay, silt, sand, and gravel, to boulder size, in fans above the Bonneville shoreline in piedmont areas; fan surfaces are less dissected than the oldest alluvial fans (QTaf); exposed thickness at least 10 feet (3 m).

QTaf Quaternary and Tertiary(?) alluvial-fan deposits (early and middle[?] Pleistocene and Pliocene[?]) - Unconsolidated to semi-consolidated, poorly sorted, mostly coarse-grained clay, silt, sand, and gravel, to boulder size, in fans on the north flank of Keg Mountain above the Bonneville shoreline; eroded into whalebacks; several hundreds of feet (30 to 90 m) thick.

Topaz Mountain Rhyolite (Miocene) - Divided into:

Ttm Rhyolite flows, domes, and intrusions - White, gray, and purplish 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 base of some flows and domes; dated at 6.3±0.1 Ma (average) in the Thomas Range by Lindsey (1982); less than about 7 million years old here; maximum exposed thickness 1,000 feet (300 m).

Ttmt Stratified tuff - Pale-tan to orange, very thick- to thin-bedded, nonwelded to fused, 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 volcaniclastic lenses beneath many Topaz Rhyolite flows and domes; extensively argillized, zeolitized, and feldspathically altered; thickness 0 to 280 feet (85 m).

Rhyolite of Keg Mountain (Miocene) - Divided into:

Tkm Rhyolite flows, domes and intrusions - Gray to dark-purple rhyolite containing abundant, large (0.4 inch [10 mm]) phenocrysts of plagioclase, and lesser amounts of sanidine, quartz, biotite, and opaque mineral phenocrysts in a matrix of devitrified glass; black vitrophyre at the base of some flows and domes; dated at 6.7±0.3 and 6.9±0.3 Ma by Plavidal (1987); maximum exposed thickness 2,000 feet (610 m).

Tkmt Stratified tuff - Pale-tan to orange, very thick- to thin-bedded, nonwelded to fused, lithic-rich, rhyolitic tuff and volcanic sandstone, with lapilli and block tuff beds; contains abundant pumice clasts, volcanic rock fragments, and sparse crystal fragments in an ash matrix; occurs as discontinuous volcaniclastic lenses beneath many flows and domes; extensively argillized, zeolitized, and feldspathically altered; thickness 0 to 300 feet (0 to 90 m).

Td Dell Tuff (Oligocene) - Pink to tan, poorly to moderately welded, crystal-rich, rhyolitic ash-flow tuff; contains abundant, 0.08- to 0. 4-inch (2- to 10-mm) phenocrysts of quartz, sanidine, plagioclase, and biotite; contains up to 19 percent volcanic rock fragments; dated at 32.0±0.6 Ma (average) by Lindsey (1982); maximum exposed thickness 600 feet (180 m), the thickest at Keg Mountain.

Trp Rhyolite porphyry (Oligocene) - Small, pale-gray to pink, light-tan weathering 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 (aphyric) 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 at base which is overlain by black fiamme-rich zone; contains abundant, 0.04 to 0.31 inch (1 to 8 mm) phenocrysts of quartz, sanidine, plagioclase, and biotite, and up to 14 percent lithic clasts of volcanic, intrusive and sedimentary rocks; dated by Shubat and Snee (1992) at 34.88±0.06 Ma; exposed thickness 80 feet (24 m).

Tpd Pebble dikes (Oligocene and Eocene) - Small (200 foot [60 m] diameter) dikes or pipes containing argillized and iron-stained clasts of Tertiary volcanic and intrusive rocks, and Paleozoic sedimentary rocks; matrix poorly exposed; only present on central west margin of map; not dated, but younger than Mt. Laird Tuff.

Tml Mt. Laird Tuff (Oligocene and Eocene) - Lavender, pale-green, dark-green, and brown, moderately welded, dacitic ash-flow tuff, tuff-breccia, 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; minor facies is accretionary lapilli-block tuff with a black, aphyric matrix; dated by Shubat and Snee (1992) at 36.54±0.06 Ma; maximum exposed thickness 240 feet (73 m).

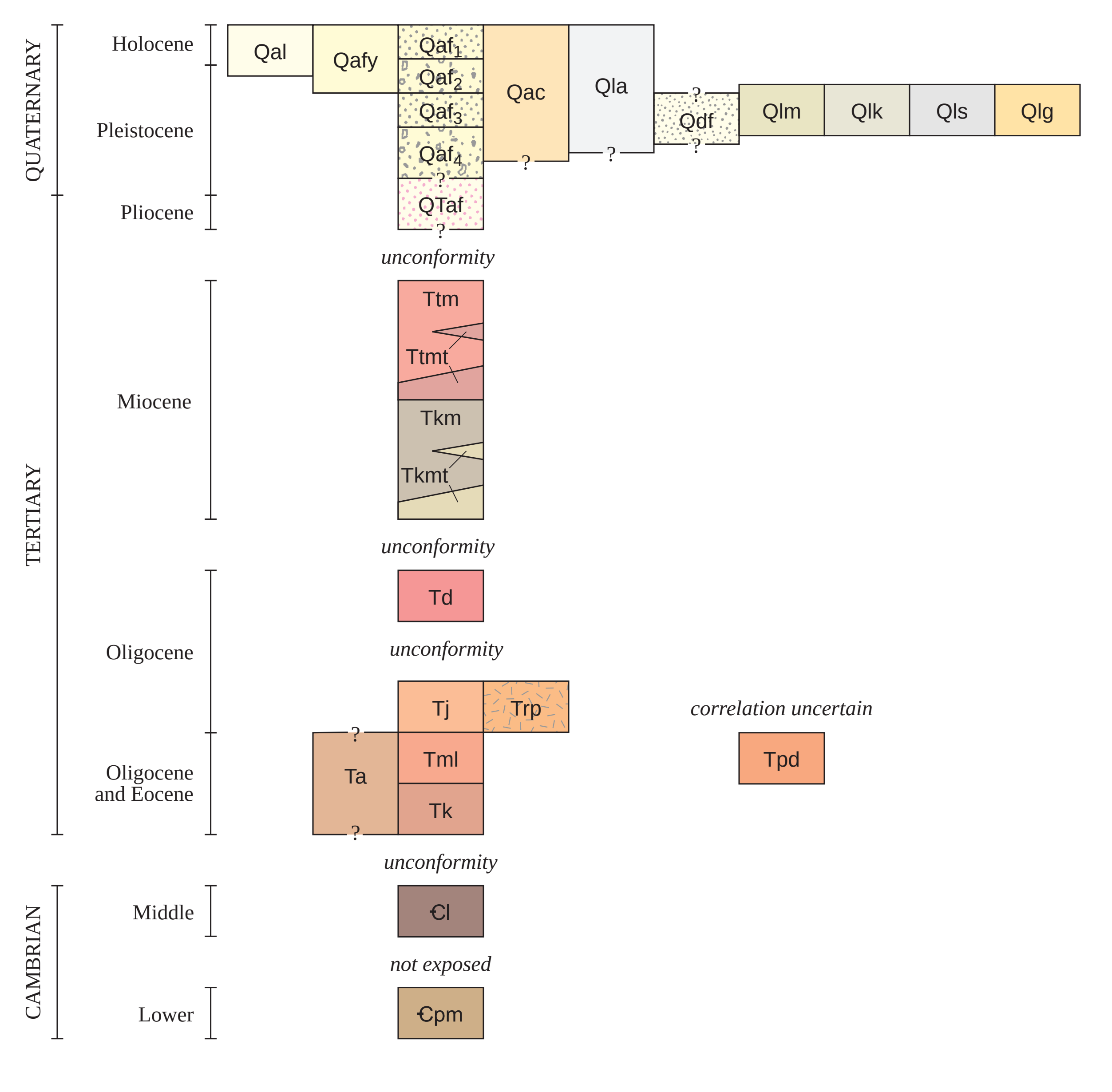
Tk Keg Tuff (Oligocene and Eocene) - Dark-red-brown to black, densely welded, moderately crystal-rich, dacitic ash-flow tuff; black vitrophyre locally present at base; abundant, bronze-weathering biotite prominent on surfaces parallel to layering; also contains plagioclase, biotite, quartz, and hornblende phenocrysts; dated by Shubat and Snee (1992) at 36.77±0.12 Ma; maximum exposed thickness 200 feet (60 m; 540 feet [165 m] thick in the Keg Pass quadrangle).

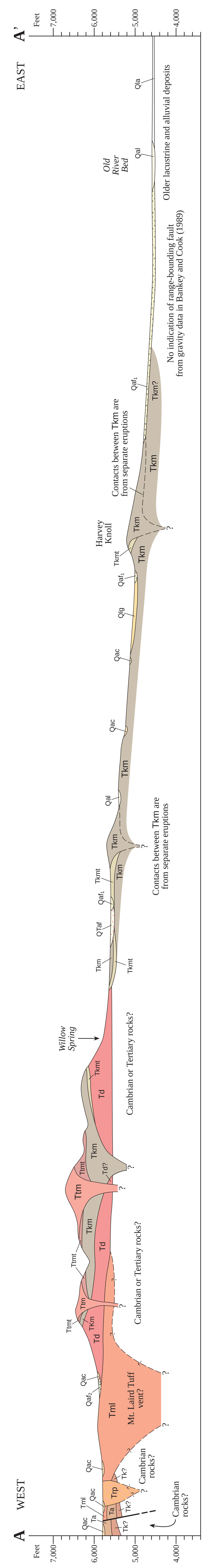
Ta Andesite of Keg Pass (Oligocene and Eocene) - Heterogeneous, dark-colored, dacitic, latitic, and andesitic flows and lesser lahars; flows contain phenocrysts of andesine, biotite, hornblende, quartz, clinopyroxene, and magnetite in a trachytic matrix; some flows contain plagioclase crystals as long as 0.6 inches (15 mm); lahars contain 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; maximum exposed thickness about 200 feet (60 m).

Ꞓl Undifferentiated Cambrian carbonate rocks (Middle Cambrian) - Light- to dark-gray, medium- to thick-bedded, biosparite limestone in isolated exposures; correlation uncertain, but probably part of the Howell Limestone, Chisholm Formation, Dome Limestone, Whirlwind Formation, or Swasey Limestone; exposed thickness less than 20 feet (6 m) thick, but up to 200 feet (60 m) thick in Keg Pass quadrangle.

Ꞓpm Prospect Mountain Quartzite (Cambrian) - Pinkish-gray to tan, rusty-weathering, medium-grained, thick-bedded quartzite with small-scale cross-bedding; pervasively brecciated in most exposures; exposed thickness 80 feet (24 m), but more than 820 feet (250 m) thick to north in Slow Elk Hills.

CORRELATION OF GEOLOGIC UNITS

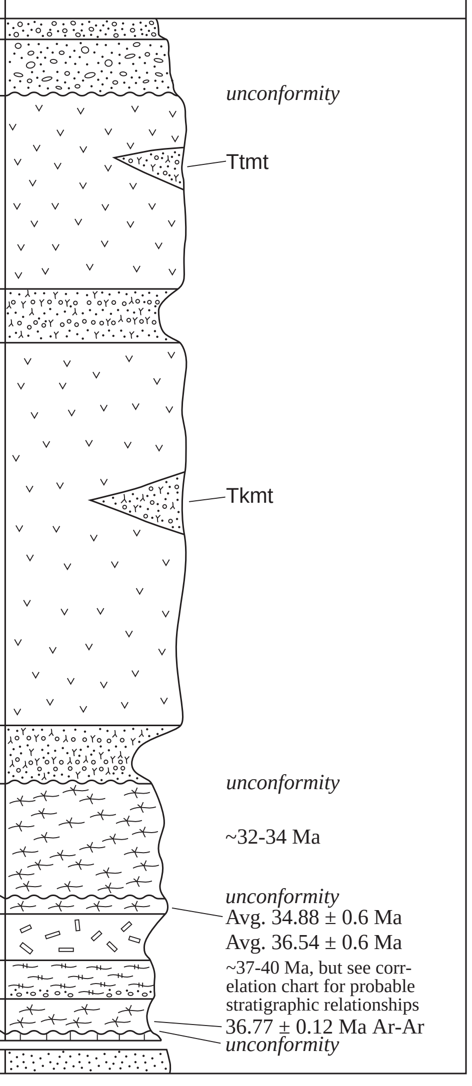




STRATIGRAPHIC COLUMN

SYSTEM	SERIES	FORMATION / MAP UNIT		SYM-BOL	THICKNESS Feet (Meters)
QUATERNARY		Quaternary deposits		Q	0-100 (0-30)
	Pliocene	Quaternary and Tertiary(?) alluvial-fan deposits		QTaf	~0-300 (~0-90)
TERTIARY	Miocene	Topaz Mountain Rhyolite	Rhyolite flows, domes, and intrusions	Ttm	0-1,000 (0-300)
			Stratified tuff	Ttmt	0-280 (0-85)
		Rhyolite of Keg Mountain	Rhyolite flows, domes, and intrusions	Tkm	0-2,000 (0-610)
			Stratified tuff	Tkmt	0-300 (0-90)
	Oligocene	Dell Tuff		Td	0-600 (0-180)
	Oligocene and Eocene?	Joy Tuff		Tj	0-80 (0-20)
		Mt. Laird Tuff		Tml	0-240 (0-73)
		Andesite of Keg Pass		Ta	0-200 (0-60)
		Keg Tuff		Tk	0-200+ (0-60+)
CAMBRIAN	Middle	Undiff. carbonate rocks		Ꞓl	20+ (6+)
	Lower	Prospect Mountain Quartzite		Ꞓpm	80+ (24+)

LITHOLOGY



MAP AND CROSS SECTION SYMBOLS

Contact - dashed where approximately located; querried on cross section where diagrammatic

High-angle fault - dashed where location inferred; dotted where covered, bar and ball on downthrown side, dip indicated where measured; dashed and queried where diagrammatic; arrows show relative direction of movement on cross section

Air-photo lineament - probable location of fault

Bonneville shoreline

Provo shoreline

70 Strike and dip of bedding

vertical 25 Strike and dip of layering in volcanic rocks

KP-6-5 Location of sample analyzed in this study (results in table 1 and appendices)

BFC Location of Bonneville flood contact exposure

KMO Location of type area of Keg Mountain oscillation

PB Location of Pahvant Butte ash exposure

A A' Line of cross section