GEOLOGIC MAP AND CROSS SECTIONS OF THE BIG HORN AND BELMONT MOUNTAINS, WEST-CENTRAL ARIZONA

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INTRODUCTION

The principal geologic feature of the Big Horn and Belmont Mountains is a complexly faulted and tilted series of mostly Miocene volcanic rock that record a period of Middle Tertiary magmatism and extension. These volcanic rocks vary widely in composition, but basaltic and rhyolitic rocks are most abundant (Figure 1). Intrusive equivalents of these volcanics exposed in the Belmont Mountains are dominantly granitic. Despite the large volume of rhyolite erupted, small, coalescing flow and dome complexes were formed in preference to large-volume ash-flow tuffs, and no collapse calderas were formed. These rocks lie in the upper plate of the regional Whipple-Bucks-in-Bullard detachment fault [Rehrig and Reynolds, 1980], at its southeastern tip [Richard et al, 1990a]. A regional boundary between major tilts domains in Tertiary strata follows an irregular course from northwest to southeast through the range [Rehrig et al., 1980]. Northeast of this boundary, strata dip to the northeast, and southwest of the boundary, Tertiary strata dip to the southwest. Pre-Tertiary rocks are exposed in several parts of the range. These rocks consist of a Laramide-age (71-63 Ma) hornblende-biotite granodiorite, informally referred to as the Big Horn granodiorite, which intrudes a complex of Proterozoic igneous and metamorphic rocks. Metamorphic grade in the Proterozoic rocks increases from southeast to northwest, and associated igneous rocks become more abundant to the northwest. In the southeast the Proterozoic rocks consist
of highly deformed, greenschist facies, mafic and pelitic schist. These grade to heterogeneous mafic-to-
intermediate-composition gneiss to the northwest.

The geology of ranges adjacent to the Big Horn Mountains has been described in recent years. The geology
of the Vulture Mountains [Grubensky, 1989] is very similar to that in the Big Horn Mountains. A relatively
undeformed Middle(?) Tertiary volcanic center crops out at Saddle Mountain, to the south of the Big Horn
Mountains [Ort and Skotnicki, 1993]. To the northwest, the Harquahala Mountains consist of Proterozoic,
Paleozoic and Mesozoic rocks in the footwall of the Buckskin-Bullard detachment fault. These rocks record a
complex history of Mesozoic deformation at low greenschist to amphibolite facies conditions, Miocene dike
intrusion, and, at the northeast end of the Harquahala Mountains, mylonitization related to the Buckskin-Bullard
detachment fault [Richard, 1988; Richard et al., 1990a; Richard et al., 1990b]. This report consists mostly of
description of the rock units in the Big Horn Mountains, with a brief discussion of the included cross-sections.
A more detailed Arizona Geological Survey Bulletin summarizing the geology of the range is in preparation, and
should follow shortly.

MAP UNITS

Late Tertiary and Quaternary deposits

Qt Talus. (Quaternary). Unconsolidated, poorly sorted, angular gravel to boulders, generally on steep
slopes.

Qs Undivided alluvial sediments. (Quaternary). Non-indurated to poorly indurated sand, silt, and gravel.
Generally includes alluvium in active channels and underlying adjacent terraces, and some talus (Qt).

Qso Older alluvium. (Quaternary). Unconsolidated gravel-poor sand and sandy gravel deposits in flood
plains elevated 0.5 to 2 m above the modern channels. Deposits typically host mature mesquite trees.

QTs Old Alluvium. (Quaternary or Tertiary). Unconsolidated to semiconsolidated and caliche-cemented
sand and gravel deposits that commonly underlie dissected terraces elevated 2 m or more above
modern drainages. These deposits are being incised by the present drainage system and host palo
verde, saguaro and other cacti.

Tertiary volcanic and sedimentary rocks

Lava flows and related tuffs were mapped separately at a scale of 1:24,000 [Capps et al., 1985], and are
distinguished on the 1:50,000-scale map when thickness permits. Silicic lava flows, domes, and minor welded
tuffs form ridges-and-cliffs, whereas more easily eroded basalts and poorly welded tuffs typically form valleys,
hummocky terrain, or pediment. Abundant section-repeating normal faults make estimation of the total
thickness of the volcanic section difficult. The average thickness of the volcanic section in individual fault
blocks is typically from 500 to 700 m. There could be a maximum of 1 to 3.5 km of Tertiary volcanic rocks in
the most complete section, exposed in a northwest-striking fault block in the Dead Horse Wash area.

Thb Hot Rock Basalt. (Miocene). Dark gray to black-colored, equigranular, moderate- to fine-grained,
vesicular basalt flows. The basalt contains rare 1 to 2 mm phenocrysts of clinopyroxene, olivine, and
plagioclase in a matrix of plagioclase, opaque oxides, and olivine (commonly rimmed by iddingsite).
Zeolites and calcite partially fill vesicles and diktytaxitic voids. The principal outcrops occur on the
periphery of the range, capping mesas and high hills. The basalt overlies gently dipping Tertiary conglomerate. The basalt yielded a K-Ar age date of 15.01 ± 0.42 Ma at Hot Rock Mountain, [Shafiqullah et al., 1980], and 15.62 ± 0.35 Ma at Black Butte in the western Vulture Mountains [Scarborough and Wilt, 1979]. Hot Rock basalt is the youngest volcanic unit in the Big Horn Mountains and was erupted after most significant regional tilting. The maximum thickness is about 20 m at Hot Rock Mountain.

**Fanglomerate. (Miocene).** Buff-colored consolidated to semiconsolidated conglomerate, conglomeratic sandstone, sedimentary breccia, landslide megabreccia, and debris flows; generally includes overlying, less consolidated, sand and gravel deposits equivalent to unit QTs. The unit commonly forms low hills with little or no outcrop, but steep cliffs a few meters high occasionally occur in washes. The deposits are flat lying to slightly tilted.

**Megabreccia and sedimentary breccia. (Miocene).** Shattered landslide blocks (megabreccia) derived from older rock units. Breccia blocks consist of virtually all rock types present in the area. Exotic quartzite and limestone blocks, interpreted to be Bolsa and Coconino quartzite, crop out along a fault near the extreme western edge of the Big Horn Mountains. Their source area is unknown. The stratigraphy of volcanic units is locally preserved in individual landslide blocks as large as several kilometers long and 100 m thick. Other areas of megabreccia display interlayering of blocks derived from Precambrian metamorphic units, Cretaceous granitoids, and Tertiary volcanic units. Megabreccia is locally associated with monolithologic and poly lithologic sedimentary breccias and debris flow deposits.

**Burnt Mountain Volcanics. (Miocene).** The Burnt Mountain Volcanics consists of several members including:

1. **Moon Anchor andesite (Tma).**
2. **Pump Mine Wash andesite (Tpa),**
3. **Upper mafic flows (Tub),** and
4. **Porphyritic andesite lavas and lahars of Burnt Mountain (Tba).**

**Burnt Mountain** appears to be an andesitic volcanic center, and may represent the source vent for one or more of the flows comprising the Moon Anchor andesite members as well as the Burnt Mountain andesite member. Reconnaissance in the Saddle Mountain and Pa lo Verde Hills area confirms the presence of at least one lava correlative with the Moon Anchor andesite.

**Moon Anchor Andesite. (Miocene).** Undivided, dark-gray to dark reddish-brown-colored, moderately to highly vesicular, porphyritic andesite flows and minor phenocryst-poor basalt. The member also contains an air-fall lapilli tuff that underlies the main andesitic lava in the southern Big Horn Mountains. The member unconformably overlies Old Camp rhyolite, Dead Horse basalt, and Hummingbird rhyolite, and is the top of section in the southern and west-central Big Horn Mountains. The Moon Anchor andesites contain 10 to 30% phenocrysts including 8 to 12% plagioclase (1-10 mm), 2 to 5% biotite (1-5 mm), <5% pyroxene and amphibole (1-4 mm), rare quartz (commonly with coronas of augite), and opaque oxides. Some of the andesites also contain 4 to 10% fine-grained quenched inclusions of a more mafic magma. Flows generally do not exceed 30 m and contain basal agglomerate and glassy horizons. Maximum exposed thickness ranges up to 150 m.

**Pump Mine Wash andesite. (Miocene).** Undivided dark- to light-gray and light-yellowish-brown-colored, fine-grained, dense andesite flows, flow breccia, basal vitrophyre, and minor lithic tuffs. The groundmass is composed of interlocking plagioclase laths with up to 10% hornblende crystals as long as 4 mm. Highly embayed quartz crystals are present in trace amounts. The Pump Mine Wash andesite overlies Dead Horse basalt and Blue Hope rhyolite along an angular unconformity. Its relationship to other members of the Burnt Mountain Volcanics is poorly known. The principal outcrops of this member occur in the central part of the map area and form high rounded knobs. The maximum thickness is <100 m. The unit equals the Mine Wash andesite of Capps et al. [1985].
Tub Aphyric basalt. (Miocene). Dark-gray-colored, fine-grained, dense, nearly aphyric basalt that contains rare pyroxene microphenocrysts and trace amounts of glomeroporphyritic inclusions, which locally contain orthopyroxene. Very fine-grained, altered olivine and anhedral opaque oxide microphenocrysts are present. The basalt has a well-developed spheroidal weathering pattern. The principal outcrop of this unit mapped by Capps et al. [1985] is present near a microwave relay station in the southwestern part of the field area. Several other northwest-trending outcrops are interpreted as inverted paleovalleys. A widespread angular unconformity exists between this member and the underlying Dead Horse basalt, Hummingbird rhyolite, and Blue Hope rhyolite. The Upper aphyric basalt is overlain by the Moon Anchor andesite. A K-Ar whole-rock age date on this unit is 16.1 ± 0.2 Ma. The member is <80 m thick.

Tba(t) Burnt Mountain andesite member. (Miocene). Consists of numerous andesite lavas, breccias, tuffs, and lahars that make up the lower slopes of Burnt Mountain and adjacent areas. The flows of the member are typically gray, black, red-brown, or yellowish-brown, with phenocrysts of plagioclase (5-15%), clinopyroxene (2-10%), orthopyroxene (2-10%), oxidized hornblende (<5%), olivine (<5%), and opaque oxides (<2%). The andesites underlie, are buttressed against, and partially overlie Hummingbird rhyolite. They are overlain by thin pyroclastic rocks and Moon Anchor andesite.

Big Horn Volcanics. (Miocene).

The Big Horn Volcanics consists of several multiple-flow rhyolitic to dacitic members intercalated with basalt flows, andesite flows, tuffs, and sedimentary and volcaniclastic rocks. These overlie crystalline basement rocks and basal Tertiary clastic sedimentary rocks (Tc), but underlie fanglomerate, megabreccia, sedimentary breccia, and nearly flat-lying Hot Rock basalt. The Dead Horse formation generally underlies, and the Burnt Mountain Volcanics generally overlie the Big Horn Volcanics, but members of the Big Horn Volcanics are interbedded locally with both these units. Angular unconformities of variable magnitude are present throughout the range, especially near the top of the stratigraphic section, and are discussed in the unit descriptions.

Most rhyolite flows are underlain by tuffs that are poorly- to non-welded and contain abundant accessory and accidental lithic fragments as large as 2 m in diameter. These tuffs generally extend <100 m beyond the margins of the overlying rhyolite flows. They are typically thinly bedded, consisting of sequences of surge, fall, and flow deposits containing planar, massive and, crossbedded horizons. Accidental lithic fragments are generally derived from local sources, and can be related to underlying units. Most tuffs probably represent phreatic or phreatomagmatic pyroclastic surge, ash-flow, and air-fall deposits.

The rhyolite flows and minor welded tuffs form ridges-and-cliffs, whereas more easily eroded basalts and poorly welded tuffs typically form valleys, hummocky terrain, or pediment. Abundant section-repeating normal faults make estimation of the total thickness of the volcanic section difficult. The average thickness of the volcanic section in individual fault blocks is typically from 500 to 700 m. There could be a maximum of 1 to 3.5 km of Tertiary volcanic rocks in the most complete section, exposed in a northwest-striking fault block in the Dead Horse Wash area.

Abundant hypabyssal rhyolite and basalt dikes intrude the prevolcanic basement rocks and commonly have phenocryst assemblages similar to those in the adjacent or overlying volcanics. Some of the dikes probably represent conduits for the volcanics, although some may postdate the main episode of volcanism.

Tbbr(t) Beer Bottle rhyolite. (Miocene). Consists of light gray to pink-colored, phenocryst-poor rhyolite flows, flow breccias, and lithic tuffs. Phenocrysts (<1 to 5%, <2 mm) are biotite, quartz, and opaque minerals. The groundmass exhibits a granophyric texture. Arqiligal alteration, moderate silicification, and fine-grained limonite pseudomorphs after pyrite are present within the matrix near the U.S. mine. Some outcrops may be remnants of small domes. The maximum thickness of the flows is about 50 m in the U.S. mine area. The lithic tuffs reach a maximum thickness of 20 m, and do not persist laterally beyond the limit of the overlying flows. This member is the top of the section in its outcrop area and overlies Dead Horse formation, Old Camp rhyolite, and Sugarloaf rhyolite with a significant angular unconformity. A sample collected on the west side of the Belmont Mountains yielded a K-Ar feldspar date of 16.4 ± 0.2 Ma.
Tbd(t) Big Horn Peak dacite. (Miocene). A gray, pink, or red, porphyritic dacite lava flow with minor flow breccia, and associated lithic air-fall and ash-flow tuffs. Flow banding is prominent, and gives the rock a platy appearance locally. Crystals include plagioclase (5-10%), hornblende (5%, commonly oxidized), biotite (2%), clinopyroxene (1-5%), and trace amounts of quartz and alkali feldspar. The member contains 2-10% fine-grained, mafic inclusions consisting of plagioclase, clinopyroxene, hornblende, and opaque minerals. The inclusions are red to pink, rounded, and are typically a few cm in size. Disaggregation of these inclusions also accounts for a portion of the phenocryst assemblage mentioned above. The flow caps Big Horn Peak, and is exposed in local outliers to the south of it. The flow overlies the Hummingbird Springs member and is over 200 m thick (with an erosion top) on Big Horn Peak.

Tsr(t) Sugarloaf rhyolite. (Miocene). Comprises light-yellowish-brown, light pink, and light-brownish-gray-colored, nearly aphyric rhyolite flows, blocky pumice flows, flow breccias, poorly welded, lithic ash-flow tuffs, and local moderately welded tuffs. About one-half of the outcrop area is vitrophyre. Sparse phenocrysts (<1 vol%) include embayed plagioclase, hornblende, biotite, and anhedral opaque minerals. The strongly flow-foliated lavas contain abundant lithophysae, especially near flow tops. Narrow sinuous cavities as long as one-half meter contain chalcedony. The rhyolite flows are generally accompanied by lithic-rich tuffs that rarely extend beyond the outcrop area of the overlying flows. At least three paired sets, each consisting of a lithic tuff and overlying lava flow, are present in the Dead Horse Wash area, and two of these pairs occur at Sugarloaf Mountain. The tuffs contain abundant accidental and accessory lithic fragments, which are as large as 2 m in diameter, but average 2.5 to 5 cm in diameter. In the northeastern Dead Horse Wash area, these tuffs contain abundant well-rounded, but locally derived lithic fragments of Upper Cretaceous granodiorite. Low-angle cross-bedding is locally present. Sugarloaf rhyolites form ridges-and-cliffs. This member overlies Dead Horse basalt and Hummingbird rhyolite with slight angular unconformity, and is overlain by Moon Anchor andesite and Beer Bottle rhyolite. Gray-colored, fine-grained basalt flows less than one meter thick are intercalated within the lower Sugarloaf rhyolite tuff on Sugarloaf Mountain. The maximum thickness of Sugarloaf rhyolite at Sugarloaf Mountain is about 200 m and the thickness is as great as 650 m in the Dead Horse Wash area.

Thr(t) Blue Hope rhyolite. (Miocene). Light-yellowish-brown, light-pink, gray, and light-greenish-gray-colored, moderately to highly porphyritic rhyolite lava flows, flow breccias, and lithic tuffs. At least one-half of the outcrop area is vitrophyre that is a mottled, very dark gray where unaltered, but light yellowish-brown to greenish-gray where altered. This member contains 8 to 25% phenocrysts, including 6 to 15% sanidine, 2 to 10% quartz (up to 5 mm), a trace to 7% hornblende (up to 7 mm), a trace to 3% biotite (1-3 mm), and trace amounts of sphene. Some flows contain plagioclase as well as sanidine. Most quartz phenocrysts are subhedral and partially embayed. Feldspar phenocrysts are subhedral to euhedral and contain few inclusions. Spherulitic devitrification is common in the upper parts of most flows. Flows containing significant hornblende phenocrysts occur near the base of the member, while flows containing abundant quartz phenocrysts are generally high in the member. Quenched mafic inclusions (trace to 10%) are present in some flows and commonly aligned in the flow foliation of the rhyolite host. The inclusions are red-brown to gray in color, round to subround in cross section, and range in size from <1 to 15 cm. The Blue Hope rhyolite is generally intercalated with Dead Horse basalt, but also directly overlies Cretaceous granodiorite and Hummingbird rhyolite in some areas. The rhyolite is conformably overlain by Dead Horse basalt, but is unconformably overlain by Pump Mine Wash andesite and aphyric basalt of the Burnt Mountain Volcanics. The principal outcrop area is between the Blue Hope mine and Dead Horse Wash. The Blue Hope rhyolite is a ridge-and-cliff former, and is <400 m thick. A K-Ar date from a hornblende-bearing flow near the base of the unit is 21.4 ± 0.3 Ma.

Thr(t) Hummingbird rhyolite. (Miocene). Light-gray, light-greenish-gray, and light-yellowish-brown-colored, porphyritic rhyolite lava flows, flow breccias, blocky pumice flows, and locally abundant lithic tuffs. About one-half of the outcrop area of the Hummingbird rhyolite is light-colored,
altered vitrophyre. The member contains 3 to 20% phenocrysts including 2 to 15% sanidine, 1 to 8% quartz, a trace to 10% biotite, a trace to 3% hornblende, and a trace of opaque minerals and pyroxene. Sanidine and quartz phenocrysts are euhedral to subhedral and moderately embayed. Biotite phenocrysts are euhedral and opaque grains are anhedral to subhedral. Glomeroporphyritic inclusions (trace to 10%) of augite, feldspar, biotite, and opaque material are present in many of the flows, especially in northwesterly striking outcrops between Woodchopper and Dead Horse Washes. Cristobalite is present as a vapor phase mineral within the matrix of flows and spherulitic devitrification is common in the interior portions of flows. 1 mm diameter amethystine quartz crystals are present in small cavities in slightly to moderately silicified Hummingbird rhyolite northwest of the Moon Anchor mine, and all of the quartz phenocrysts are amethystine in a Hummingbird rhyolite flow near the head of Blue Wash in the eastern Big Horn Mountains. The lower flow at Hummingbird Springs yielded a K-Ar biotite date of 20.3 ± 0.2 Ma. Hummingbird rhyolites are intercalated with Dead Horse basalt; locally, however, they directly overlie Precambrian schist, Cretaceous granodiorite, Old Camp rhyolite, and Morningstar rhyolite. The member is overlain by Dead Horse basalt, Blue Hope rhyolite, Sugarloaf rhyolite, Big Horn Peak dacite, Moon Anchor andesite, or Beer Bottle rhyolite. It forms steep cliffs and ridges, and principally crops out between the Moon Anchor mine and Big Horn Peak. In its main outcrop area, the member is over 450 m thick, although its base is not exposed.

Tor(t) Old Camp rhyolite and dacite. (Miocene). Medium- to light-gray and reddish-brown, light-pink, lavender, light yellowish-brown, and brownish-red colored, moderately vesicular, porphyritic rhyolite, rhyodacite, and dacite flows and associated lithic tuffs. The rhyolite flows contain 15 to 20% phenocrysts, including 8 to 15% plagioclase (1-5 mm, commonly 4-5 mm), 5 to 12% biotite, 1 to 8% quartz, a trace to 1% clinopyroxene, a trace to 8% hornblende, and a trace of spherene. Some flows contain fine-grained, quenched mafic inclusions, and coarse-grained, glomeroporphyritic mafic inclusions with crystals of clinopyroxene, plagioclase, biotite, and opaque minerals. Local, light-yellowish-brown, hydrated basal vitrophyres <15 m thick are associated with the rhyolite flows. Cogenetic lithic tuffs and tuffaceous sediments, 20 -300 m thick underlie and overlie the flows. Most of the flows are partially K-metasomatized. About one third of the groundmass and most of the plagioclase phenocrysts are altered. In hand specimen, the alteration is recognized by a mottled appearance of the groundmass and altered plagioclase cores. Rhyolite flows in the southeastern Old Camp Wash area are least altered. The Old Camp volcanic member overlies Precambrian schist, Morningstar rhyolite, Dead Horse formation, and the basal sandstones, conglomerate, and volcaniclastic rocks. This member is intercalated with Dead Horse formation, and is overlain with a 20° or more angular unconformity by Moon Anchor andesite and Beer Bottle rhyolite. The Old Camp volcanic member may be >1 km thick in the northeastern Old Camp Wash area, but average 350 to 500 m thick. This member is a strong ridge-and-cliff former. A K-metasomatized sample collected just north of the U.S. mine area yielded a K-Ar biotite age of 19.6 ± 0.2 Ma.

Tmr(t) Morningstar rhyolite. (Miocene). Pink, light-yellowish-brown-colored, dense, strongly flow-foliated, phenocryst-poor rhyolite lava flows, minor flow breccias, and local poorly welded ash-flow tuffs. The rhyolite lavas generally contain <2% phenocrysts of biotite, quartz, moderately to strongly altered plagioclase (1 to 3 mm diameter), and anhedral opaque oxide minerals in a fine- to medium-grained, granophyric groundmass. A quartz-rich group of flows are included in the unit in the southern Big Horn Mountains. Secondary quartz and light-green fluorite fill locally abundant fractures. This member is a ledge and-ridge former and it is the lowest rhyolite flow of the Big Horn Volcanics. The principal outcrop area is about 3.3 km southwest of the western Belmont Mountains. The rhyolite variably overlies Dead Horse formation and Precambrian schists and is overlain by Dead Horse formation and the Old Camp volcanic member. The maximum thickness is about 140 m.

Dead Horse formation. (Miocene). The Dead Horse formation overlies basal Tertiary sedimentary rocks and Precambrian metamorphic and Cretaceous intrusive rocks. The basalts are interbedded with the
lower members of the Big Horn Volcanics, but not the Big Horn Peak, Sugarloaf, or Beer Bottle members. The total thickness of the unit is generally <50 m, but Capps et al. [1985] estimated its thickness at >300 m in the Dead Horse Wash area. The basalt member is commonly absent in portions southern Big Horn Mountains and the Hummingbird rhyolite member of the Big Horn Volcanics locally rests directly on biotite-bearing andesitic rocks (Tda) included in the Dead Horse formation. In the western Big Horn Mountains, pervasively brecciated and K-metasomatized basalt correlated with the Dead Horse formation is found in isolated outcrops directly overlying pre-Tertiary rocks. In the Lion's Den mine area the unit contains abundant sandstone and conglomerate layers (Tds). The thickness of the unit in the Lion's Den area may exceed 100 m.

Tdb Basalt. (Miocene). Dark-gray, dark-green, and reddish-brown, vesicular to massive, porphyritic to nearly aphyric basalt flows, flow breccias, and cinder beds. The basalts contain 2 to 20% phenocrysts, including 2 to 10% olivine, 2 to 15% clinopyroxene, 2 to 5% plagioclase, and more rarely <3% orthopyroxene. Opaque oxide grains and fine-grained olivine are abundant in a matrix of flow-foliated plagioclase laths. Glomerophenocrysts consisting of olivine, clinopyroxene, biotite, and plagioclase are present in a few flows. Locally the basalt is very vesicular. Basalt in the northwestern part of the range, is correlated with the Dead Horse formation based on lithological similarity. A distinctive, dark gray, olivine-biotite andesite(?), present in Black Queen area in the northwestern part of the range, contains 3-5% 2-3 mm diameter biotite phenocrysts.

Tdt Tuff. (Miocene). Pink, reddish-brown, white, light-green welded to nonwelded felsic tuffs and tuffaceous sedimentary rocks forming thin ridges and ledges. Tuffs typically contain phenocrysts of sanidine, quartz, and biotite. These may be distal equivalents of rhyolites in the lower part of the Big Horn Volcanics.

Tds Sandstone and conglomerate. (Miocene). Red, reddish-brown, and brown arkosic and lithic sandstone and conglomerate. Sandstone is red-brown to tan, fine- to coarse-grained, very poorly sorted, feldspathic quartz arenite. Thin, discontinuous mudstone partings are locally present. Sedimentary structures include plane laminations, low-angle cross beds, and medium-scale trough cross beds. Sparse buff-colored, plane laminated, tuffaceous sandstone is present. The sandstones grade into grit, pebbly sandstone and cobble conglomerate. Clasts in the conglomerates include a variety of well-rounded granitoids, some of which resemble units Xlg and Xbg, others of which are unlike granitoids of the Big Horn or adjacent Harquahala Mountains. Other clast types are basalt resembling unit Tdb, and pink, welded tuff. The tuff contains 2% 1 mm quartz, plagioclase and K-feldspar phenocrysts; unflattened bubble (non-welded) shards are visible. Clasts of this tuff are up to 50 cm in diameter. Rare debris flows consist of an arkosic sandstone matrix supporting angular basalt clasts. The thickest units of interbedded clastic rocks are present in the northwestern part of the range, in sections that are not continuous with the more complete sections in the central part of the range mapped by Capps et al. [1985]. Thus, the stratigraphic position of the interbedded clastic rocks relative to the Big Horn Volcanics can not be determined.

Tda Andesite. (Miocene). Red, reddish-brown, brown, and green-gray massive to vesicular, platy, andesite flows and breccias. The andesites contain <2 to 15% phenocrysts of biotite, amphibole, clinopyroxene, plagioclase, and opaque oxide minerals in a groundmass dominated by flow aligned plagioclase microphenocrysts. This member makes up the base of the section in the Big Horn Peak area, but basalt lavas are present locally.

Tc Sandstone and conglomerate. (Miocene or Oligocene). Reddish-brown to greenish-gray-colored coarse sandstone, conglomerate, and debris flows. Clasts are of Precambrian metamorphic and intrusive rocks, Cretaceous intrusive rocks, and rare basalt. Clasts are typically angular to sub angular. These clastic sedimentary rocks are generally <1 m thick, but are up to 30 m thick in the Dead Horse Wash area. They are poorly indurated and nonconformably overlie Precambrian metamorphic and Cretaceous intrusive rocks and are overlain by Dead Horse basalts and basaltic sediments. Conglomerate occurring on the extreme western edge of the Big Horn Mountains contains abundant angular clasts of Paleozoic (?) quartzite and limestone in addition to typical basement rock types.
This conglomerate appears to have a different provenance than other mapped exposures of the Tc unit.

### Tertiary intrusive rocks

Tertiary intrusive rocks in the map area include: (1) the Belmont granite, interpreted as a shallow plutonic equivalent to silicic lavas, and (2) the abundant hypabyssal rhyolite and basalt dikes and sills that intrude the pre-volcanic basement rocks of throughout the Big Horn and Belmont Mountains. Some of these latter rocks have phenocryst assemblages similar to those in the adjacent or overlying volcanic rocks, and probably represent conduits for the volcanic rocks, however some dikes and sills may postdate the main episode of volcanism (cf. Grubensky, 1989).

**Ti**  
Felsic intrusive rocks. (*Miocene*). Undivided intrusive rocks as described below.

**Tiq** Quartz-rich rhyolite. (*Miocene*). Light-gray, light-yellowish brown, and light-pink-colored, fine-grained rhyolite dikes. These dikes contain as much as 30% phenocrysts of sanidine, quartz, hornblende, and lesser amounts of biotite and accessory minerals. Some of these dikes contain quenched mafic inclusions (up to 15%) ranging in size from <1 cm to 15 cm. In thin section the dikes have a fine- to medium-grained granophyric texture. Several dikes in the Blue Hope mine area contain abundant vesicles in their upper portions and grade into highly vesicular breccias. These dikes clearly represent feeders to Blue Hope and Hummingbird rhyolite flows in this area. Quartz-rich dikes are most abundant in Cretaceous granodiorite near the Blue Hope mine, but also intrude Proterozoic rocks and Dead Horse basalts sporadically through the range. Most of these dikes are K-metasomatized, and many are intensely brecciated within the structures that they intruded.

**Tif** Feldspar-rich rhyolite. (*Miocene*). Light-colored fine-grained rhyolitic dikes with 1 to 20 mm feldspar phenocrysts (3-15%) and less abundant quartz phenocrysts. The matrix of the dikes varies from fresh to extensively altered.

**Tih** Hornblende-bearing rhyolite. (*Miocene*). Pink, gray, and light-brown rhyolitic dikes with up to 20% hornblende, typically accompanied by feldspar, and less commonly, by quartz and biotite. These dikes are most common in basement rocks that stratigraphic underlie the Blue Hope and Hummingbird members.

**Tia** Aphyric rhyolite. (*Miocene*). Light-pink and light-gray-colored, fine-grained rhyolite intrusions with rare quartz or feldspar phenocrysts.

**Tim** Mafic to intermediate intrusive rocks. (*Miocene*). Dark green to olive, brown, and black-colored aphanitic to medium-grained basaltic, andesitic, and dioritic dikes that generally are extensively altered, and poorly exposed, except in mine workings and in washes.

**Tbg** Belmont granite. (*Miocene*). Light-colored, generally medium-grained, equigranular granite that forms bold, rounded outcrops with only minor soil cover. The granite is generally leucocratic (<1% biotite and magnetite) and contains approximately 40% quartz (1-4 mm), locally as discrete phenocrysts. The granite is composed of the following phases: (1) medium-grained, equigranular granite that contains a trace of biotite or magnetite; (2) fine- to medium-grained, leucocratic granite and granophyre with abundant mafic cavities rimmed by terminated crystals of quartz, orthoclase, epidote, muscovite, and purple fluorite; and (3) fine-grained, leucocratic granite granophyre with scattered quartz phenocrysts and mafic cavities. Sphene is also present locally in the medium-grained phase of the granite.
Cretaceous intrusive rocks

Ki  Fine-grained felsic dikes. (Cretaceous). Light-colored, fine-grained, equigranular dikes commonly associated with Cretaceous granodiorite and granite.

Big Horn granodiorite

Kg  Main phase. (Cretaceous). Light-gray, gray, and tan coarse- to medium-grained granodiorite averaging approximately 30% plagioclase, 30% potassium feldspar, 5 to 12% biotite, >10% quartz, and trace amounts of sphene, opaque oxide minerals, and other accessory minerals. Locally grades into gray, or pink equigranular medium to fine-grained granite. This pluton has complex contacts with Proterozoic rocks, typically with a dioritic border phase along the northwest side and a granitic border phase along the northeast side. Numerous irregular apophyses of the intrusion project into adjacent Proterozoic metamorphic rocks. Sparse biotite-rich xenoliths are present. The K-Ar date on biotite from a sample of granodiorite collected in the Dead Horse Wash area is 70.8 ± 0.5 Ma. Biotite K-Ar dates of 63 ± 1.9 and 68 ± 2.0 Ma were determined for the similar granite in the Big Horn Mountains Wilderness [Miller and Gray, in press]. The pluton crops out in a ENE-trending belt through the northern part of the Big Horn Mountains, and forms very poor outcrops, typically making up small grus-covered hills and pediment.

Kgp  Porphyrytic phase. (Cretaceous). Granite to monzogranite with abundant K-feldspar megacrysts up to 4 cm long. Locally grades into equigranular varieties. Some of the best outcrops are located along the southwestern front of the range in the Big Horn Wilderness.

Kd  Border phase. (Cretaceous). Dioritic border phase, consisting of hornblende and plagioclase; sphene is significantly more abundant than in main phase (Kg). Occurs as irregular small bodies scattered in Proterozoic country rock on the northwest side of the pluton, and along and near the northwest margin of the pluton. Grain size is quite variable, ranging to very coarse-grained hornblendite. Some small bodies are agmatitic. Locally appears to grade into foliated amphibole-rich Proterozoic rocks. This may be due to deformation of partially crystalline intrusion margins during emplacement, partial assimilation of wall rock, or mafic-felsic magma interaction at intrusion margins. As a result, mapping of some contacts is only approximate.

Paleozoic sedimentary rocks

Pzu  Upper Paleozoic sediments, undivided. (Permian and Pennsylvanian) Supai Formation, Coconino Quartzite, Kaibab Limestone undivided, in inverted and strongly deformed section at western edge of range. Probably lies beneath the Eagle Eye detachment fault.

Pzl  Lower Paleozoic sediments, undivided. (Mississippian through Cambrian) Bolsa Quartzite, Abrigo Formation, Martin Formation, Redwall limestone, undivided, on small hill at western edge of range. Depositional contact at base of Bolsa Quartzite is preserved on small hill to SE of larger hill with near complete Paleozoic section.

Proterozoic rocks

Xfg  Equigranular granodiorite to monzogranite. (Early Proterozoic). Fine to medium fine-grained granitoid with about 5% biotite in flakes up to 2 mm in diameter. The rock contains a very weak fabric and outcrops show spheroidal weathering when not altered. Forms a 2 km² homogeneous pluton in the Pegrin well area. This body is cut by very weakly deformed pegmatite dikes. Contains
5-10% amphibolite inclusions as discrete xenoliths. Non-resistant granitoid weathers to grus, leaving surface littered with float of more resistant dikes and inclusions, giving a false impression of the nature of the bedrock. Near it borders the granitoid becomes texturally more variable and more leucocratic (~1% biotite) and resembles unit Xlg. Intrudes compositional banding in wall rock-gneisses (S1); the foliation in this pluton corresponds to a younger (S2) fabric observed in the gneisses.

Xbg  Biotite granitoid. (*Early Proterozoic*). Medium- to medium fine-grained, equigranular, biotite monzogranite to granodiorite. Foliation is variably developed, ranging from weak and irregular to a well developed, uniform shape fabric and biotite schistosity. Consists of 30-40% quartz, 10-20% potassium feldspar, 40-60% plagioclase, 4-10% biotite, trace sphene. Relatively unfoliated zones weather spheroidally. As with Xlg, rarely occurs as homogeneous masses, but is normally in heterogeneous, texturally variable mixed zones with abundant wall rock inclusions, many of which are partially resorbed. Rare, sharp contacts vary from concordant to discordant. Gradational mixed contacts are the most common; compositions grade both to the gneissic diorite component of Xag or Xga and to Xlg leucogranite.

Xlg  Leucogranite. (*Early Proterozoic*). Fine-grained equigranular, aplitic monzogranite, contains 1-2% biotite, 25-35% quartz, 20-35% K-feldspar, 40-55% plagioclase. Generally does not form discrete bodies. Weak foliation defined by faint biotite alignment, and by compositional and textural variations. Intrudes the more mafic phases of the Proterozoic igneous complex in the NW Big Horn Mountains as thin dikes or small irregular plutons. Locally forms relatively homogeneous bodies (5-10% inclusions), but in general is characterized by abundant wall rock inclusions and textural and compositional gradation to more mafic phases. Mapped as Xlg when >50% of rock is judged to be leucogranite, but the heterogeneity of the rocks makes this and all contacts within and around this igneous/metamorphic complex quite subjective. Contact zones with gneissic wall rocks commonly contain abundant pegmatite as irregular pods and stringers. The pegmatites consist of quartz and feldspar, with little muscovite.

Xg  Mixed granitoids. (*Early Proterozoic*). Mixed Xlg and Xbg in variable, but subequal proportions; amphibolite inclusions are common.

Xga  Mixed granitoids and amphibolite. (*Early Proterozoic*). Leucogranite (Xlg) and biotite granitoid (Xbg) mixed with 10-50% amphibole-rich gneiss (like that in Xag). Contacts into Xlg, Xbg and Xag are gradational with varying proportions of granitic and metamorphic components.

Xag  Mixed amphibolite and granitoids. (*Early Proterozoic*). Amphibole-rich gneiss mixed with 10-50% leucogranite and biotite granitoid; leucogranite generally subordinate to biotite granitoids. Gneiss component is fine-grained amphibole-plagioclase gneiss with well developed planar fabric defined by aligned amphibole and laminated compositional banding of amphibole- or plagioclase-rich layers, or locally by 1-15 cm thick quartz-feldsparic layers. Ranges from homogeneous amphibolite gneiss to mixed amphibolite and amphibole-plagioclase-biotite-(quartz) gneiss with concordant and discordant granitic lithosomes.

Xm  Mafic gneiss. (*Early Proterozoic*). Mafic gneiss includes compositionally banded hornblende-rich gneisses ranging from amphibolite to plagioclase-biotite-hornblende gneiss. The typical gneiss is fine-grained and equigranular, with 2-15 cm thick bands defined by plagioclase-rich and plagioclase-poor layers. The foliation is generally quite regular. Foliated gabbro or diorite bodies and aphanitic to very fine-grained white quartz-feldspar granofels that contain sparse 2-3 mm quartz porphyroclasts are a minor component.

Xa  Amphibolite. (*Early Proterozoic*). Dark-green and greenish-gray to black, massive, fine-grained hornblende schist, consisting of 50-80% hornblende with variable amounts of plagioclase, chlorite, epidote and biotite. Light-greenish quartz-epidote layers and lenses of muscovite rich schist are locally present. Grades to northwest into Xag unit with increasing metamorphic grade and granitoid intrusion.
Xgn  Heterogeneous intermediate-composition gneisses. (Early Proterozoic). Compositionally variable feldspar-quartz-biotite-amphibole gneiss. In the SW, consists of fine-grained, feldspar-quartz-biotite-amphibole gneisses, with variable mineralogy. These are gradational with amphibolite gneiss (Xm and Xag), which forms a significant component of the assemblage in this area; both are probably part of the same original protolith assemblage. A minor component in this assemblage is fine-grained, quartz-feldspar gneiss with 1-3% biotite, and irregular nebulitic foliation. To the NE, two sorts or quartz-feldspar-biotite gneiss become prominent. Both are fine-grained and contain 25-35% quartz, 40-60% plagioclase, minor K-feldspar, and 3-5% biotite. One is slightly finer-grained (1-2 mm), and contains a foliation defined by anastomosing, discontinuous biotite-rich laminations spaced 1-10 cm; rare K-feldspar porphyroblasts are present. The other consists of 2-3 mm grains, possibly with slightly more K-feldspar, and a foliation defined by more planar and continuous biotite laminations; plagioclase in this gneiss weathers white to give weathered surfaces a characteristic speckled appearance. Both types of gneiss contain highly flattened inclusions of amphibolite and intermediate gneiss that resemble deformed igneous xenoliths. These gneisses are interpreted to be highly deformed and metamorphosed granodioritic plutons that intruded the older gneiss assemblage represented by the feldspar-quartz-biotite-amphibole gneisses in the southwestern part of the unit. Textural reworking and mixing of these compositionally similar rock bodies during metamorphism and deformation makes separation of the units on the map impractical without more detailed study. Units Xgn and Xag are interpreted to represent a mafic to intermediate volcanic/plutonic terrane that experienced intense deformation and metamorphism before and during intrusion of the igneous complex represented by Xlg and Xbg. Intermediate to silicic components of the igneous complex are intermixed in varying proportions (<50%) throughout this unit. Includes units Xm of Capps et al. [1985].

Xs  Schist and phyllite. (Early Proterozoic). Light-green, gray-green, and brown fine- to medium-grained, muscovite-rich schist and phyllite. The unit includes feldspar-muscovite-chlorite-epidote schist, plagioclase-chlorite schist, calc-silicate gneiss or hornfels; and less abundant ferruginous-quartzite layers a few meters thick. The protolith includes silicic to intermediate volcanic rocks, volcaniclastic units, quartzose feldspathic-lithic sandstones, pelitic rocks, and ferruginous cherts. Relict depositional structures (bedding?, fragmental textures) are rarely visible. A well-developed, northeast-striking, steep continuous cleavage is present throughout in the micaceous units. The unit is commonly monotonous on a 1-10 m scale, but displays significant lithologic variation on a larger scale. The contact with amphibole-rich schist is gradational over several 10's of meters. The two units are interleaved near the contact.

**Cross sections**

Cross sections accompanying this map were drawn at a scale of 1:24000, using data from Capps et al. [1985] and other, more recent mapping used to compile this 1:50,000-scale map. The more detailed scale of the cross sections allows more of the stratigraphy to be shown on the cross sections, providing a better indication of the data used in preparation of the accompanying reconstructed cross sections. The reconstructed sections were used to estimate the magnitude of extension within the range. Tertiary volcanic rocks in the map area were erupted before, during, and after a period of early to middle Miocene extension. Faulting and tilting associated with this extension produced a pattern of mostly northwest-striking Tertiary strata, cut by an array of northwest-striking normal faults and north- to northeast-trending transverse faults with poorly constrained slip. Tertiary strata dip to the northeast in the northeastern part of the range, and to the southwest in the southwestern part of the range [Rehrig et al., 1980; Spencer and Reynolds, 1986]. The boundary between northeast- and southwest-dipping domains is discontinuous and irregular (see Figure 2). It is formed by a combination of northeast-trending transverse zones and by northwest-trending antiformal dip reversals. The northeast-trending transverse zones offset the reversal zone with both right and left separations. Several of these northeast-trending zones are arrays of intersecting, short fault segments, few or which are oriented northwest, which together define a north- to northeast-trending dip-domain boundary. At the
northwestern end of range, the dip reversal occurs across an anticline that plunges NW, suggesting reverse drag on the Eagle Eye segment of the Buckskin-Bullard detachment fault.

Table 1 summarizes the magnitude of extension expressed both in total km of extension and in the percent

<table>
<thead>
<tr>
<th>Section line</th>
<th>post-extension length l (km)</th>
<th>pre-extension length l (km)</th>
<th>km extension</th>
<th>% extension (l/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-A'</td>
<td>16.2</td>
<td>9.9</td>
<td>6.2</td>
<td>63%</td>
</tr>
<tr>
<td>B-B'</td>
<td>24.1</td>
<td>17.6</td>
<td>6.6</td>
<td>38%</td>
</tr>
<tr>
<td>C-C'+D-D'</td>
<td>26.7</td>
<td>21.6</td>
<td>5.1</td>
<td>24%</td>
</tr>
<tr>
<td>E-E'</td>
<td>18.6</td>
<td>14.1</td>
<td>4.5</td>
<td>31%</td>
</tr>
<tr>
<td>G-G'</td>
<td>7.7</td>
<td>5.6</td>
<td>2.1</td>
<td>38%</td>
</tr>
</tbody>
</table>

Lengths were measured between points indicated by arrows on cross sections.

Figure 2. Map showing tilt domains in the Big Horn and Belmont Mountains. Arrows in pattern indicate the direction of tilting of Tertiary strata. The pattern of faults and contacts from Figure 1 is screened in the background for reference. The heavy dashed and dotted black line is the boundary between generally NE-dipping and SW-dipping strata.
Table 2. Age dates from Big Horn and Belmont Mountains.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Rock type</th>
<th>Unit</th>
<th>method</th>
<th>material</th>
<th>Date</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 84WAB140</td>
<td>basalt</td>
<td>Deadhorse basalt</td>
<td>KA</td>
<td>w.r.</td>
<td>19.80 ±0.8</td>
<td>33° 36.00'</td>
<td>113° 7.33'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>2 84WAB17</td>
<td>monzonite</td>
<td>Big Horn granodiorite(?)</td>
<td>KA</td>
<td>biot</td>
<td>68.10 ±2.0</td>
<td>33° 37.67'</td>
<td>113° 7.68'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>3 84WAM23</td>
<td>rhyolite</td>
<td>Hummingbird mbr, Big Horn volcanics</td>
<td>KA</td>
<td>biot</td>
<td>18.50 ±0.6</td>
<td>33° 38.55'</td>
<td>113° 10.75'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>4 84WAM30</td>
<td>basalt</td>
<td>Burnt Mountain volcanics, 'upper basalt'</td>
<td>KA</td>
<td>w.r.</td>
<td>18.80 ±0.5</td>
<td>33° 38.75'</td>
<td>113° 6.92'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>5 84WAM73</td>
<td>rhyolite</td>
<td>Hummingbird mbr, Big Horn volcanics</td>
<td>KA</td>
<td>biot</td>
<td>20.20 ±0.8</td>
<td>33° 34.83'</td>
<td>113° 6.32'</td>
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<tr>
<td>6 853-26-1A</td>
<td>granodiorite</td>
<td>Big Horn granodiorite</td>
<td>KA</td>
<td>biot</td>
<td>70.80 ±0.5</td>
<td>33° 46.14'</td>
<td>113° 3.00'</td>
<td>Spencer et al., 1995</td>
</tr>
<tr>
<td>7 85WAM40</td>
<td>rhyolite</td>
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<td>KA</td>
<td>biot</td>
<td>63.00 ±1.9</td>
<td>33° 38.63'</td>
<td>113° 8.78'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>8 86WAG001</td>
<td>rhyodacite tuff</td>
<td>Burnt Mountain volcanics?</td>
<td>KA</td>
<td>biot</td>
<td>20.00 ±0.6</td>
<td>33° 32.37'</td>
<td>113° 3.33'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>9 86WAG002</td>
<td>andesite</td>
<td>Burnt Mountain volcanics</td>
<td>KA</td>
<td>w.r.</td>
<td>17.70 ±0.6</td>
<td>33° 32.37'</td>
<td>113° 3.50'</td>
<td>Miller and Gray, in press</td>
</tr>
<tr>
<td>10 BH-89</td>
<td>basalt</td>
<td>Burn Mountain volcanics, 'upper basalt'</td>
<td>KA</td>
<td>pl_c</td>
<td>16.10 ±0.2</td>
<td>33° 41.44'</td>
<td>113° 5.68'</td>
<td>Spencer et al., 1995</td>
</tr>
<tr>
<td>11 BHC-212</td>
<td>rhyolite</td>
<td>Hummingbird mbr, Big Horn volcanics</td>
<td>KA</td>
<td>biot</td>
<td>20.30 ±0.2</td>
<td>33° 39.26'</td>
<td>113° 5.03'</td>
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<td>12 BHC-213</td>
<td>rhyolite</td>
<td>Blue Hope mbr, Big Horn volcanics</td>
<td>KA</td>
<td>biot</td>
<td>21.40 ±0.3</td>
<td>33° 43.28'</td>
<td>113° 5.31'</td>
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<tr>
<td>13 BHC-215</td>
<td>rhyodacite</td>
<td>Old Camp mbr, Big Horn volcanics</td>
<td>KA</td>
<td>biot</td>
<td>19.60 ±0.2</td>
<td>33° 44.59'</td>
<td>113° 1.88'</td>
<td>Spencer et al., 1995</td>
</tr>
<tr>
<td>14 UAKA-73-10</td>
<td>basalt</td>
<td>Hot Rock basalt</td>
<td>KA</td>
<td>w.r.</td>
<td>15.01 ±0.4</td>
<td>33° 35.14'</td>
<td>112° 52.83'</td>
<td>Shafiquullah and others, 1980</td>
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<tr>
<td>15 853-20-3</td>
<td>granite</td>
<td>Belmont granite</td>
<td>SR</td>
<td>w.r.</td>
<td>20.00</td>
<td>33° 38.00'</td>
<td>112° 53.00'</td>
<td>Spencer et al., 1995</td>
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<tr>
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<td>rhyolite</td>
<td>Beer Bottle rhyolite</td>
<td>KA</td>
<td>feld</td>
<td>16.40 ±0.2</td>
<td>33° 38.26'</td>
<td>112° 54.83'</td>
<td>Spencer et al., 1995</td>
</tr>
<tr>
<td></td>
<td>rhyolite</td>
<td>Beer Bottle rhyolite</td>
<td>KA</td>
<td>feld</td>
<td>16.70 ±0.2</td>
<td>33° 38.26'</td>
<td>112° 54.83'</td>
<td>Spencer et al., 1995</td>
</tr>
</tbody>
</table>

*--indicates samples whose location is uncertain; the rock unit on the map at the reported location is different from what was reported to have been dated.

1 Belmont granite sample location is only reported to nearest minute. Age reported is model age based on assumed initial ratio of 0.709.

Abbreviations: Dating methods: KA-potassium argon; SR--rubidium-strontium. Material dated: biot--biotite; feld-feldspar; pl_c--plagioclase concentrate; sani--sanidine; w.r.--whole rock.
Table 1 summarizes the magnitude of extension expressed both in total km of extension and in the percent of extension for five transects across the map area. Since all the sections do not cross the entire range, comparing the results requires comparing the parts of the range covered by the sections. Extension measured for section C-C' was added to extension measured on the southwest end of D-D' (southwest of the fault that juxtaposes Tub and Tdb) and is shown on the table as composite section C-C'+D-D'. Section A-A' does not include the relatively unextended rocks at the southwestern edge of the range (Big Horn Peak area). These rocks are included on sections B-B' and C-C'+D-D' which reduces the % extension for these sections. The total km of extension does not change significantly between A-A' and B-B', and is slightly reduced for composite section C-C'+D-D'. Section E-E' crosses the entire range, and the extension estimated for this section is less than that for section C-C'+D-D'. Section G-G' includes the equivalent of only about half the extended terrane included in the other sections, and the paucity of Tertiary rocks along this section makes the qualitative uncertainty in this estimate larger than for the other sections. Together, these reconstructions indicate that the total change in width of the range due to extension (if-li) decreases from ~6.4 km to ~4 km in the 15 km between section A-A' and G-G'.

Dramatic stratigraphic variations occur across the large normal fault in the central part of the range indicating syn-depositional movement on this fault. Thickening of the Dead Horse basalt and Old Camp rhyolite southwestward towards this fault suggests initial movement was down on the northeast. Thickening of the Blue Hope rhyolite and overlying megabreccia and fanglomerate to the northeast on the southwest side of this fault indicates that final movement was down on the southwest. Alternatively, the crystalline basement rocks exposed in the central part of the range may form a horst between two normal faults (the northeastern one unrecognized in the area of section A-A'). The lower part of the Tertiary stratigraphic section is poorly exposed in the northeastern part of sections A-A', B-B', and C-C', allowing for various interpretations of the stratigraphic relations. Sections A-A' and B-B' were reconstructed by inferring dramatic thickness variations in the volcanic units. Section C-C' was reconstructed with 100-200 m of relief on the unconformity at the base of the Tertiary section to show an alternate possibility.

GEOCHRONOLOGY

Available isotopic age dates for rocks within the map area are located on the map. Each point on the map is labeled with an identifying number, a two letter code for the isotopic system used to obtain the date, an apparent age, and an uncertainty. Where two or more mineral fractions from the same sample were analyzed, these are show on consecutive lines. Table 2 provides more information about these ages dates. Abbreviations used on the map are explained below the table.

REFERENCES


Miller, R. J., and Gray, F., in press, Potassium-Argon ages in the western Big Horn Mountains, Maricopa County, Arizona, in Geology of the Big Horn and Belmont Mountains, Arizona Geological Survey Bulletin.


