COMPILATION GEOLOGIC MIAP OF THE CENTRAL GILA BEND MOUNTAINS, MARICOPA COUNTY, ARIZONA

by
Steven J. Skotnicki

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416 W. Congress, Suite #100, Tucson, Arizona 85701

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INTRODUCTION

This report includes the area between Webb Mountain and Yellow Medicine Butte in the central Gila Bend Mountains, approximately 30 kilometers northwest of Gila Bend, Arizona. The study area includes part of the Woolsey Peak Wilderness Study Area, all of the Signal Mountain Wilderness Study Area, and the following four U.S.Geological Survey, 1:24,000 scale 7.5' topographic quadrangles; Fourth of July Butte, Gillespie, Quail Spring Wash, and Woolsey Peak (Plate 1; Figure 1). Several well-graded dirt roads provide access to much of the area but do not extend into the wilderness areas. The Agua Caliente Road is the major artery slicing east-west through the center of the map area. There is also a good service road paralleling the Southern Pacific Railroad, and several well-kept roads in the Harquahala Plain and east of Mullen's Cut (Figure 2).

Field work was carried out during October/November, 1993, and March, 1994. Though many areas were mapped in detail at 1:24,000 scale, much of the geology was only mapped at a reconnaissance level and, hence, the map is generalized. Most of the surficial deposits were mapped using color 1:24,000 scale and black-and-white 1:100,000 scale aerial photographs, combined with field work. The bedrock geology was compiled from my work and the work of others. Their work has been modified and, in the case of the Signal Mountain and Woolsey Peak Wilderness areas, has been remapped. This project was jointly funded by the Arizona Geological Survey and the U.S. Geological Survey STATEMAP Program, contract #1434-93-A-1144.

PREVIOUS INVESTIGATIONS

In part of a report about the geology of the Lower Gila River region Ross (1922, 1923) described the general geology in the area west of Woolsey Peak and along the modern-day Agua Caliente Road. In the northeast part of the study area the Palo Verde Hills were mapped as part of a study for the Palo Verde Nuclear Generating Station (Schoustra et al., 1976). Schoustra and others also obtained three radiometric dates on the young, flat-lying basalt west of Woolsey Peak. The Proterozoic rocks of the Webb mountain area, which includes the Webb mineral district as defined by Keith et al. (1983), was mapped first by Cheeseman (1972) and later by Northrup and Reynolds (1991). Scott (1991) mapped in detail the northwest part of the study area between Gillespie and Fourth of July Butte. In 1971 Noranda Exploration, Inc., drilled a series of holes around the Dixie/Jackpot mines and produced a report containing drill logs and columnar sections of the area. In the southeast, the Signal Mountain Wilderness Study Area was mapped very generally at about 1:50,000 scale (Gray and others, 1989) and its mineral potential investigated by Kreidler (1986). Assessments of mineral resource potential and generalized geologic maps of the Woolsey Peak Wilderness Study Area were produced by McDowell (1986) and Peterson and others (1989a), and a reconnaissance geologic map (1:48,000) was produced by Peterson and others (1989b).

Demsey (1989, 1990) mapped the surficial deposits in the map area at 1:100,000 scale. General reconnaissance surveys were also incorporated into the state geologic map by Wilson and others (1969). Bordering the map to the north, the Saddle Mountain area was mapped by Ort and Skotnicki (1993). To the west Gilbert and Skotnicki (1993) mapped the region around Cortez Peak, and to the east, Gilbert (1991) mapped the eastern Gila Bend Mountains.

GEOLOGIC SETTING

The Gila Bend Mountains, located within the Basin and Range physiographic province, consist of a broad northwest-trending belt of low hills. Though locally the relief in the region exceeds 2000 feet, it more typically is on the order of several hundred feet. The highest point in the area is Woolsey Peak which reaches an elevation of 3171 feet. The region is dissected by many broad washes which drain both southward into the Gila River and northeastward into Centennial Wash.

The bedrock consists mostly of Miocene volcanic rocks (Plate 1; Figure 3). Clastic sedimentary rocks and local sedimentary breccias that overlie pre-Tertiary bedrock are overlain by mafic lava flows in northwestern areas and by rhyolite porphyry in the central part of the map area. Felsic to intermediate volcanic rocks of the Signal Mountain area in the central part of the map area may be the oldest Tertiary volcanic rocks exposed (Figure 4). Tilted rhyolite and rhyolite porphyry lavas interbedded with basal sedimentary rocks (map units Tsc and Tc) are overlain by a thick rhyolite porphyry (map unit Trp) which itself is overlain by basalt (map unit Tbl) and a thick sequence of resistant, cliff-forming andesite flows (map unit Ta). An unpublished K-Ar hornblende age of 20.7$\pm$0.6 Ma from a sample of felsic to intermediate volcanic rocks near Signal Mountain (Peterson and others, 1989b) was probably from andesite (map unit Ta). The andesite includes domes (one of which is visible immediately northwest of Signal Mountain) and is locally interbedded with well-exposed bedded lithic tuffs (map unit Ttl) at Signal Mountain. Felsic volcanic rocks on the south side of Saddle Mountain at the north edge of the map area, which may be the same age as the Signal Mountain felsic volcanic rocks, consist of multiple flows of tan to pink biotite-hornblende dacite intercalated with basalt.

Tilted basalt and basaltic andesite (map unit Tbm) cover much of the western half of the range. Originally interpreted as Cretaceous in age (Wilson and others, 1969; Reynolds, 1988), the rocks have since been reinterpreted as Tertiary (Scott, 1991). These mafic volcanic rocks form a thick, northeast-dipping, moderately- to highly-faulted sequence thought to be between 1-2 km thick (Scott, 1991), that unconformably overlies the felsic volcanic rocks of the Signal Mountain area. The lenses of dacitic and andesitic tuff within the mafic sequence are interpreted as younger than, and not correlative with, the lithic tuffs at Signal Mountain (map unit Ttl), a correlation suggested by Scott (1991).

Overlying most of the rocks in the area are younger, dark blue-grey, mesa-forming basalt flows. They were not strongly affected by faulting but have been cut and tilted slightly in many areas by high-angle normal faults. Rocks of this age are regionally widespread and have been dated, north of the map area, at 15.0 Ma (Shafiqullah and others, 1980). The basalt is locally interbedded, typically near the base, with well-bedded yellow tuff and light pink welded tuff. The welded tuff appears to thicken towards Bunyan Peak, though it pinches out locally, and is probably equivalent to the younger welded tuff south of Bunyan Peak in the Painted Rock Mountains (map unit Tva of Skotnicki, 1993). Because map units Tbu and Tbm are very similar it was difficult to locate their contact. In general, though, the middle basalts have been altered and typically contain plagioclase phenocrysts that have been variably altered to calcite, clay minerals, and/or sericite. Most of the olivine phenocrysts in map unit Tbm have also been altered to red opaques, probably iddingsite. On the other hand, the younger basalts have not been extensively altered. The plagioclase phenocrysts are relatively fresh, though much olivine has been altered to red opaques. As a result of the alteration the older basalts are generally redder than the younger basalts. Also, locally, younger basalts are separated from the underlying middle basalts by yellow lithic tuff (map unit Ttu). Where attitudes are clear the younger basalts dip less steeply than the middle basalts and commonly in the opposite direction.

An much younger basalt that crops out southwest of Woolsey Peak is dark grey, vesicular, relatively fresh and unfaulted. At least one and possibly two vents have been identified. They are associated with spatter ramparts composed of welded scoria and depressions, though altered by erosion, which were probably the vents themselves. The unit has been dated in three locations by Schoustra et al.(1976) at 2.58 Ma, 4.60 Ma, and 6.70 Ma. This younger basalt is most likely related to several other young basaltic shield volcanoes in southwest Arizona between Arlington and Sentinel (Scarborough and others, 1986)

SEDIMENTARY ROCKS

Sedimentary rocks are aerially extensive, though generally poorly exposed. They are generally less resistant than the volcanic rocks and erode into low hills covered by coarse lag and alluvium. Most of the sedimentary rocks consist of red, thinly-bedded arkosic sandstone and conglomerate, locally interbedded with breccia, siltstone, shale, and limestone. Volcanic clasts are rare to absent in the clastic units, indicating that the sediments were deposited prior to and/or at the beginning of volcanic activity (Figure 5). Common folds in shale and siltstone layers have amplitudes typically around 1-2 meters. The sedimentary rocks rest nonconformably on crystalline basement. No evidence of low-angle faulting was observed at the contact near Forth of July Butte. An interbedded tuff just west of the study area, along the Agua Caliente Road has yielded a biotite K-Ar date of 23.7 Ma (Scarborough and Wilt, 1979). Shale, sandstone and conglomerate northwest of Signal Mountain are interbedded with thin flows of rhyolite and rhyolite porphyry, all of which appear to dip more or less radially away from central outcrops of diorite and granite. Monolithic granitic and rhyolitic breccia within basal clastic sediments consist of poorly-sorted, angular to subrounded clasts cemented by a light red sandy matrix.

There are other outcrops of breccia, most of which are not shown on the map, near Fourth of July Butte and Dixie Mine. At the Dixie mine large cobbles and blocks of dark to medium grey quartz-feldspar porphyry form part of the prominent hill at the mine. South and east of the mine there are isolated exposures of quartz-feldspar breccia and volcanic breccia, probably created along fault zones. Also, at Fourth of July Butte outcrops of volcanic breccia may be associated with faulting. There is also one small exposure of quartzite megabreccia near Fourth of July Wash which may have been derived from Paleozoic quartzite (Scott, 1991).

Ross (1922) stated that there is 30-foot-thick exposure of sandstone interbedded with limestone at Woolsey Tank. I could not locate the exact location of this exposure, but from the photographs in his report, and from a location map in a later report (Ross, 1923), it appears to be in the vicinity of modern-day Woolsey Spring.

On the southwest side of Woolsey Peak a several-hundred-foot-thick breccia consists of very poorly sorted sand- to boulder-size clasts of felsic and mafic volcanic rocks and rare granite and diorite clasts. It is locally inversely graded with stratification most visible from a distance. Most of the clasts have a rind of desert varnish, even on unexposed surfaces, suggesting that the clastic detritus was exposed on the surface for some time before becoming incorporated into the deposit.

Conglomerate, which thickens to the southeast, overlies crystalline rocks on the south side of Webb Mountain. Though not shown on the map it is interbedded with basalt and yellow bedded tuff (see figure 6). East of the study area also at the southern edge of Webb Mountain are a few other very limited exposures of conglomerate and sandstone. The deposits appear to rest nonconformably on Proterozoic metamorphic rocks and, like the sedimentary rocks to the west, dip between 20 and 30 degrees to the southwest.

Less than 1 km south of the Idazona Mines, at Jagow Tank, well-exposed light blue-grey limestone (map unit Tsl) overlies crystalline basement and is itself overlain by red conglomerate. The limestone is locally well-bedded and contains a myriad of red and grey chert nodules. In this respect it resembles Mississippian Redwall Limestone, but it does not appear to shiny recrystallized texture seen on fresh surfaces of the Redwall Limestone. The limestone forms light grey, weathered outcrops surrounded by red soil.

INTRUSIVE AND METAMORPHIC ROCKS

Most of the crystalline basement is exposed along the northern edge of the mountain range and consists of foliated dark green diorite (map unit Xd) and nonfoliated granite. Most of the granite contains muscovite, except for exposures near Webb Mountain, Fourth of July Butte and in the northern part of the study area southeast of Saddle Mountain. Near Fourth of July Butte the granite is rich in hornblende, which is typically altered to chlorite, and appears relatively nonfoliated, though pervasively fractured (map unit JXg). It is similar in composition to the foliated granite/granodiorite west of the map area but because it does not appear to be strongly foliated it is interpreted to be younger, possibly Mesozoic in age. Southeast of Saddle Mountain three small outcrops of granite contain abundant fresh biotite (map unit TXg). The granite there is fine-grained, equigranular, nonfoliated and is cut by both felsic and mafic dikes.

Southeast of Webb Mountain a sequence of Proterozoic metavolcanic and metasedimentary rocks has been interpreted as siliciclastic marine deposits (Northrup and Reynolds, 1991). They exhibit a pervasive northeast-striking foliation which overprints an older west- northwest foliation especially visible in the plutonic rocks. These layered rocks are similar to rocks in the younger Proterozoic volcanic belts of central Arizona, especially the Alder Group and rocks in the McDowell and Phoenix Mountains (Northrup and Reynolds, 1991).

The youngest intrusive rock in the area is a hypabyssal intrusion located between Black Butte and the Dixie Mine (map unit Ti). It is lithologically similar to the rhyolite porphyry lavas near Signal Mountain. However, it is nonconformably overlain by pre-volcanic sedimentary rocks at the Dixie Mine area, indicating that the pluton is older that the rhyolite. The pluton contains lenses of older granite and is locally overlain by small isolated outcrops of sandstone, some of which are rich in white feldspar clasts which appear to be derived from the pluton.

STRUCTURE

Northwest-striking high-angle normal faults dominate the region and have created parallel northeast-dipping fault blocks. Most of the faulting occurred before eruption of the younger mesa-forming basalts (map unit Tbu) and did not affect the youngest basalt (map unit QTb) southwest of Woolsey Peak at all. The middle basalt (map unit Tbm) and the felsic volcanic rocks typically dip 20°-60° northeast, whereas the younger basalts typically dip less than 15 degrees.

Locally, sedimentary rocks near Webb Mountain, Signal Mountain and Fourth of July Butte dip to the west and southwest, instead of to the northeast. Their attitudes may reflect early tilting during the infilling of newly-created fault-bounded basins prior to volcanism. Northwest of Signal Mountain at least one steep angular unconformity is well-exposed between underlying steeply tilted siltstone and sandstone and overlying tilted rhyolite porphyry. The presence of monolithic breccias within the sedimentary rocks were probably derived from steep slopes, possibly fault scarps.

MINERAL DEPOSITS

Almost all mineralization occurs along the northern edge of the mountain range, though not everywhere associated with older plutonic rocks. In the Webb Mountain area quartz-tourmaline alteration and quartz-chrysocolla-cuprite veins in small faults suggest remobilization and alteration of previously strata-bound volcanogenic sulfide deposits by younger hydrothermal circulation (Northrup and Reynolds, 1991). The mineral deposits have undergone metamorphism and deformation and are probably Proterozoic.

At the Butte Mine and Idazona Mines chrysocolla occurs within quartz-carbonate veins in dark green diorite. The veins strike between N15°W and N30°W and dip steeply (75°-85°) to the southwest. The veins are quite abundant, usually between 2 and 30 cm thick, and are commonly composed almost completely of grey to yellow carbonate. The carbonate is resistant and forms small ridges in the diorite. Their west-northwest strike suggests that the quartz-carbonate veins may have filled Tertiary faults or fractures, though it is possible they may be related to the older west- northwest foliation.

Around the Dixie and Jackpot Mines most mineral deposits are hosted in moderate- to high-angle fault zones (Scott, 1991). Quartz-calcite veins are common and often exhibit argillitic selvages several meters thick. Other mineralization includes chrysocolla, pyrite (and other copper sulfides and oxides), barite, and minor fluorite and wulfenite. Calcite is commonly manganiferous. Mineral deposits lie within fractures in quartz-feldspar porphyry and mafic volcanic rocks but do not appear to occur in younger basalt and andesite units, and are therefore Miocene in age. Scott (1991) suggests that mineral deposits were remobilized from older Mesozoic/Proterozoic basement rocks by circulating hydrothermal fluids.

Barite also occurs in the Yellow Medicine Hills (north of Gillespie) as a vein cutting middle basalts. The vein consists of massive sheets of closely-spaced, fibrous barite crystals separated from one another and from neighboring sheets by a dark reddish-grey fine-grained matrix which may be hematite, manganiferous calcite, or both. The vein trends roughly north-northeast and does not cut the younger basalt. Traces of chrysocolla are also visible.

One small pit dug at the contact between rhyolite porphyry and overlying older basalt west of Signal Mountain contains chrysocolla and calcite, but mineralization was not observed elsewhere along the contact.

The Hargan, Izadona, and Dixie/Jackpot Mines also produced small amounts of gold, silver and lead (AZGS file data).

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UNIT DESCRIPTIONS

Qy **Younger alluvium (Holocene)** -- Moderately well-sorted, unconsolidated sand and gravel in modern drainages.

Qp **Fine-grained alluvium (probably Holocene or Late Pleistocene)** -- Tan-colored silt and clay, estimated to be at least 5 meters thick. Locally cross-bedded and possibly eolian in origin. Erodes into badlands and sandy bluffs. Overlies coarse gravel and sand derived mostly from foliated granodiorite.

Qt **Talus (mostly Holocene)** -- Poorly sorted, angular to subrounded gravel to boulders mantling the slopes of hills. Most clasts are basalt (map unit Tbu).

Qm **Middle alluvium (Late to Middle Pleistocene)** -- Poorly to moderately consolidated, poorly to moderately well-sorted alluvium above the level of the youngest drainages. Usual forms slightly indurated terraces.

Qo **Older alluvium (Middle to Early Pleistocene)** -- Strongly caliche-cemented, moderately sorted to poorly sorted alluvium. Generally occurs as light-colored caliche-capped surfaces 5-10 meters thick resting on top of basin-fill deposits (Tsy), much higher than the level of the younger drainages.

QTb **Basalt (Quaternary to Late Tertiary)** -- Dark grey, vesicular, massive to fine-grained basalt containing 1 to 2 mm long phenocrysts of clear plagioclase and dark grey-green pyroxene. The pyroxene crystals are partly altered to a red opaque, probably iddingsite. The rock is very resistant and difficult to break. The unit has not been affected by faulting. Exposures are mostly covered by a thin cover of fine-grained alluvium. Occurs as a small shield volcano with at least one and possibly two vents, located about 3 km southwest of Woolsey Peak. Dated at 2.58 Ma, 4.60 Ma, and 6.70 Ma (Schoustra et al., 1976) and is part of the Sentinel-Arlington volcanic field (Scarborough et al., 1986)

Tsy **Younger sedimentary deposits (Late Tertiary)** -- Tan-colored, poorly sorted to moderately sorted, moderately consolidated to well-consolidated sandstone and conglomerate. Flat-lying and unfaulted. Excellent exposures in the southwest reveal dips of 4 degrees and less to the south-southwest. This unit can be subdivided into three subunits based on clast types: deposits containing dominantly Proterozoic foliated granodiorite west of Fourth of July Wash; deposits containing dominantly basaltic clasts east of Forth of July Wash; and deposits containing both clasts of Proterozoic granite/diorite and felsic/mafic volcanic rocks north and northwest of Webb Mountain. All subunits are highly dissected and typically form steep, rounded ridges.

Tbu **Younger basalt (Tertiary)** -- Medium to dark bluish-grey, massive to vesicular basalt. Typically fine-grained with clear plagioclase phenocrysts 1 to 2 mm long, locally with 1 to 5 mm olivine phenocrysts mostly altered to iddingsite. Vesicles are commonly filled with zeolite or calcite. The unit typically forms steep hills and mesas mantled by talus.

Txv **Woolsey Peak breccia (Tertiary)** -- Moderately to strongly consolidated, tan-colored volcaniclastic conglomerate and breccia. Clast- and matrix-supported. Matrix is light tan sand and silt, but locally may be tuffaceous. Contains clasts of felsic and mafic volcanic rocks and rare granite and green diorite. Clasts are mostly subrounded to subangular and many individual clasts exhibit a varnished rind, even when unexposed, indicating they were exposed on the surface for some time before being incorporated into the breccia. Crudely stratified and locally inversely-graded.

Ttw **Welded Tuff (Tertiary)** -- Pink to lavender welded tuff containing 0.5 to 2 mm phenocrysts of plagioclase, biotite, and less abundant hornblende. Biotite and hornblende crystals are locally fresh, though more typically partly to completely altered to iron oxides.

Phenocrysts constitute 10-20% of the rock. The unit is only moderately welded locally and appears yellow and well-bedded. The unit is resistant and commonly forms a small cliff where exposed. The tuff is thickest near Bunyan Peak, but appears to terminate rapidly due east of Bunyan Peak just south of the map area. Probably equivalent to map unit Tva to the south in the Painted Rock Mountains (Skotnicki, 1993).

Ttw_2 **Lower welded tuff (Tertiary)** -- Tan-colored welded tuff containing clear plagioclase phenocrysts less than 1 mm long and moderately abundant lithic fragments of yellow and purple andesite between 1-10 mm long. Strongly indurated and resistant. Forms a steep rounded ridge covered by angular debris northeast of Bunyan Peak.

Ttu **Upper Tuff (Tertiary)** -- Yellow to light tan, bedded lithic tuffs containing sand- to gravel-sized subrounded clasts of mafic and felsic volcanic rocks. Exposed typically at or near the base of the younger basalt (map unit Tbu). Some exposures may be nonwelded tuff (map unit Ttw).

Tbm **Middle basalt (Tertiary)** -- Red, grey and dark purple mafic to intermediate volcanic rocks. The unit is fine- to medium-grained and contains phenocrysts of plagioclase and less abundant olivine, pyroxene and hornblende. Most of the mafic minerals have been altered to iddingsite. Sericite, clays, and calcite have replaced parts of the plagioclase crystals and up to about 30% of the groundmass. The unit is locally interbedded with yellow bedded tuff, notably north of Forth of July Butte. These rocks form low rolling hills punctuated by small buttes.

Tt **Tuff (Tertiary)** -- Yellow to tan airfall tuff, tuffaceous sediments, and surge deposits interbedded with map unit Tbm. The unit is generally lithic-rich and contains clasts of mafic and felsic volcanic rocks.

Tta **Andesitic tuff (Tertiary)** -- Light grey to yellowish-grey andesitic tuff with up to 5% subhedral to euhedral plagioclase crystals and rare pyroxene and opaque minerals. Unit is interbedded with map unit Tbm and is exposed on ridges near Forth of July Butte. The maximum thickness of the unit is 35-40 meters.

Tda **Dacite, rhyodacite, and andesite, undivided (Tertiary)** -- Dacite and rhyodacite consisting of dark reddish-grey to reddish pink flows and tuff with 1 to 5% subhedral plagioclase phenocrysts and 0 to 3% anhedral quartz phenocrysts. Andesite consists of light green-grey flows and tuff, containing 10% subhedral to euhedral plagioclase phenocrysts partially altered to calcite and clay, 3 to 5% subhedral to euhedral pyroxene, and 1 to 2% opaque minerals. The rocks appear to be interbedded with map unit Tbm and form small hills.

Ttl **Lower tuff (Tertiary)** -- Lithic-rich tuff containing subangular clasts of andesite, basalt, and rare green diorite 1-50 mm in diameter. The unit is tan to pale yellow and forms steep cliffs. Exposures are limited to Signal Mountain where the tuff is interbedded with andesite flows and below a dome. Bedding is visible in the exposure north of Signal Mountain.

Ta **Andesite (Tertiary)** -- Pink to dark purple andesite flows. The flows contain variable amounts of clear plagioclase, hornblende and biotite phenocrysts all 1-10 mm in diameter and constitute 2 to 20% of the rock. Flows are locally discernable from one another by their differential weathering. Most flows are dense and hard, and break into thick, platy blocks. The unit is very resistant and forms the steep hills and cliffs characteristic of the eastern half of the Signal Mountain Wilderness Area. An age of 20.7 ± 0.6 Ma (Peterson and others, 1989b) was probably obtained from this unit.

Trp **Rhyolite porphyry and rhyolite (Tertiary)** -- Light blue-grey, pink, purple, and light green rhyolite porphyry containing subhedral to euhedral phenocrysts of white feldspar (orthoclase?), biotite, hornblende, and clear quartz. Feldspar is locally partly clear and is the most abundant phenocryst, constituting up to 25% of the rock. Phenocrysts are generally fresh. All phenocrysts are roughly equal in size, 2-5 mm, though biotite is commonly smaller. In the east, near Webb Mountain, quartz is absent and the mafic minerals are altered to hematite. West and northwest of Signal Mountain the unit weathers into light blue-grey hills which, from a distance, resemble mafic rocks. The rocks form steep, rugged hills in exposures west of Signal Mountain. Both rhyolite and rhyolite porphyry are interbedded with sedimentary rocks northwest of Signal Mountain.

Tbl **Lower basalt (Tertiary)** -- Basalt associated with rhyolite porphyry (map unit Trp) in the Signal Mountain area. Dark brown and purple-grey basalt containing 0.5-2 mm long clear to white plagioclase phenocrysts. The unit is both massive and vesicular, with zeolite and calcite lining the vesicles, and is locally interbedded with andesite and rhyolite porphyry. Some thin interbeds are not shown on the map. Forms steep slopes.

Tf **Biotite-hornblende dacite (Tertiary)** -- Pink to grey dacite in the Saddle Mountain area containing 1 to 10 mm long phenocrysts of subhedral to euhedral biotite, hornblende, and plagioclase. Phenocrysts are very fresh. Locally, on fresh surfaces the rock appears vitrophyric and bluish-grey. Weathered surfaces are tan to pink. The unit is interbedded with basalt (map unit Tbo).

Tbo **Older basalt (Tertiary)** -- Blue-grey to dark brown basalt in the Saddle Mountain area that contains 1 to 5 mm long phenocrysts of clear plagioclase and olivine and/or pyroxene altered to iddingsite. Interbedded with Tf and, locally, with sandstone and conglomerate (labeled Tc). Similar to map unit Tbl.

Tsc **Sandstone and conglomerate (Tertiary)** -- Undivided, interbedded, arkosic sandstone, thinly-bedded red siltstone, rare limestone, and conglomerate. Contains clasts of Pre-Tertiary plutonic and metamorphic rocks and rare Tertiary volcanic rocks. Locally, near Fourth of July Butte, the unit may be tuffaceous near its top. Siltstone and sandstone beds are locally folded, with fold amplitudes on the order of several meters. The rocks generally weather into low hills, commonly covered with clastic debris and older alluvium.

Tc **Conglomerate (Tertiary)** -- Red, grey and green sand to boulder conglomerate. Contains clasts of pre-Tertiary plutonic and metamorphic rocks and rare Tertiary basaltic volcanic rocks. Clasts are generally well-rounded and moderately well-sorted to poorly-sorted, ranging in size from granules to one meter across. The unit is massive to crudely layered. Locally interbedded with siltstone and sandstone. Locally forms dark-colored rounded hills covered with rounded cobbles.

Tx **Sedimentary breccia (Tertiary)** -- Sedimentary deposits composed of poorly-sorted angular clasts in a fine-grained clastic matrix. This unit can be subdivided into at least two types of deposits: monolithic breccias composed of either volcanic or plutonic clasts; and heterogeneous breccias composed of various rock types. Monolithic breccias crop out within sedimentary deposits (map unit Tsc) northwest of Signal Mountain. Individual deposits contain either subangular, poorly-sorted clasts of muscovite granite or rhyolite porphyry. Breccias of quartz-feldspar porphyry crop out at the Dixie Mine. Near Forth of July Butte heterogenous breccias include mafic and felsic volcanic rocks. Several exposures are only meters across and have not been included on the map.

Tsl **Limestone (Tertiary)** -- Massive to bedded light blue-grey limestone that is well-exposed west of Webb Mountain and south of Idazona Mines. Where visible, beds are between 10 and 30 cm thick. Fresh surfaces are grey to dark bluish-grey. Red chert is abundant and occurs as 1- 50 mm red and grey nodules. The chert is more resistant than the limestone and sticks out in relief on weathered surfaces. No fossils were visible though some chert nodules resemble shells. The unit overlies Proterozoic diorite and resembles Mississippian

Redwall Limestone, except that it does not display the characteristic recrystallized texture of the Redwall Limestone.

Ti **Hypabyssal intrusion (Tertiary)** -- Tan to brownish-grey aphanitic intrusion containing subhedral to euhedral white feldspar phenocrysts 1 to 6 mm long and very small crystals of quartz, biotite and hornblende. Feldspar phenocrysts constitute between 15 and 30% of the rock. The unit contains large lenses or pods of Proterozoic granite near Gillespie and is cut by mafic dikes. The intrusion is lithologically similar to rhyolite porphyry lavas near Signal Mountain (map unit Trp), but correlation seems unlikely because the intrusion is overlain by clastic sedimentary rocks (map unit Tsc), which are interbedded with and underlie the rhyolite porphyry. The unit weathers into low, light tan-colored hills.

TXg **Biotite granite (Proterozoic or Tertiary)** -- Fine- to medium-grained, equigranular granitoid in the Saddle Mountain area containing crystals of light pink to white feldspar (plagioclase$\pm$orthoclase), subhedral fresh biotite, and less abundant subhedral hornblende, all 1-10 mm in diameter. On weathered surfaces the rock is dark grey and biotite is golden-green. Fresh surfaces are medium to dark grey. Weathers spheroidally into large blocks. Exposed surfaces are commonly crumbly, developing a thin grus locally. This unit is exposed in four isolated outcrops southeast of Saddle Mountain.

JXg **Granite (Proterozoic or Mesozoic)** -- Granitoid containing crystals of white subhedral feldspar, clear anhedral quartz, and black to green subhedral hornblende and biotite, all from 1 to 8 mm in diameter. Mafic minerals are mostly altered to chlorite, though fresh locally. The granite is exposed north and west of Fourth of July Butte and can be distinguished from the Proterozoic gneiss to the west by its general lack of foliation. However, foliation is visible locally which may indicate that this was a syntectonic pluton, the nonfoliated areas being those that intruded last, after deformation.

Xg **Granite (Proterozoic)** -- The composition of this unit varies from granite to granodiorite/quartz monzonite to quartz diorite. Near Webb Mountain it is quartz diorite. Most exposures are fine- to medium-grained and relatively equigranular, though slightly feldspar-porphyritic versions occur locally. The rocks generally contain plagioclase, microcline, less abundant hornblende, and biotite or muscovite or both. Locally, hornblende is altered to biotite and chlorite. In other areas biotite is altered to hematite and stains the rock a rusty orange color. Muscovite is locally abundant and occurs as anhedral to subhedral masses up to 1 cm wide which exhibit a light green sheen on weathered surfaces. The unit appears nonfoliated except locally, and has been described as locally foliated farther east (Peterson and others, 1989b). A biotite K-Ar age of 984$\pm$39 Ma from gneissic granite about 5 miles east of the study area was reported by Eberly and Stanley (1978).

Xd **Diorite (Proterozoic)** -- Dark green, fine- to medium-grained, equigranular to weakly porphyritic diorite. This rock contains plagioclase, quartz, microcline, dark green amphibole mostly altered to chlorite, and minor apatite and zircon. The unit forms low hills with blocky outcrops which are best exposed west of Webb Mountain. The diorite exhibits both an older west-northwest-trending foliation and a younger northeast-trending foliation, though they are not everywhere well-exposed (Northrup and Reynolds, 1991).

Volcanic-Sedimentary sequence at Webb Mountain
(see Northrup and Reynolds, 1991)

Xv **Mafic to intermediate metavolcanic rocks (Proterozoic)** -- Undivided.

Xms **Metasedimentary rocks (Proterozoic)** -- Quartzite and conglomeratic quartzite. These rocks are locally interbedded with metarhyolite and contain graded beds 3 to 30 cm thick and are locally cross-bedded.

Xr **Metarhyolite (Proterozoic)** -- Tan-colored sericite schist with equant quartzose phenocrysts 2-5 mm in diameter. Flows, where distinguishable, are 5 to 20 meters thick. The bottom 100 to 200 meters of the section in the area of the Buckeye Copper Mine (just east of the study area) includes sericite, quartz, pyrophyllite, and locally tourmaline schist. This unit also locally contains 5 to 15% strata-bound volcanogenic pyrite and chalcopyrite.

Xrd **Metadacite (Proterozoic)** -- Dacite and rhyodacite containing phenocrysts of 0.5-2 mm long plagioclase and 5-15 mm long hornblende which is mostly altered to chlorite and biotite.

Xm **Mafic sills (Proterozoic)** -- Dark green porphyritic mafic sills that consist of 2-5 mm phenocrysts of amphibole in a fine-grained to aphanitic, dark green to grey matrix.

Xgw **Metagreywacke (Proterozoic)** -- Metamorphosed greywacke composed of quartz grains and volcanic lithic fragments from 1-10 mm wide in a poorly sorted matrix of chlorite, muscovite, and quartz with minor biotite. The greywacke is gradational with slates and phyllites composed of chlorite, muscovite, and quartz. Carbonate is present as silty layers 0.1 to 50 cm thick. Some of the carbonate has been redistributed into thin, anastomosing layers, probably by fluid migration. Ferruginous chert is present as a distinctive, 2- to 10-meter-thick, fairly continuous marker horizon in the upper half of the sequence (from Northrup and Reynolds, 1991).

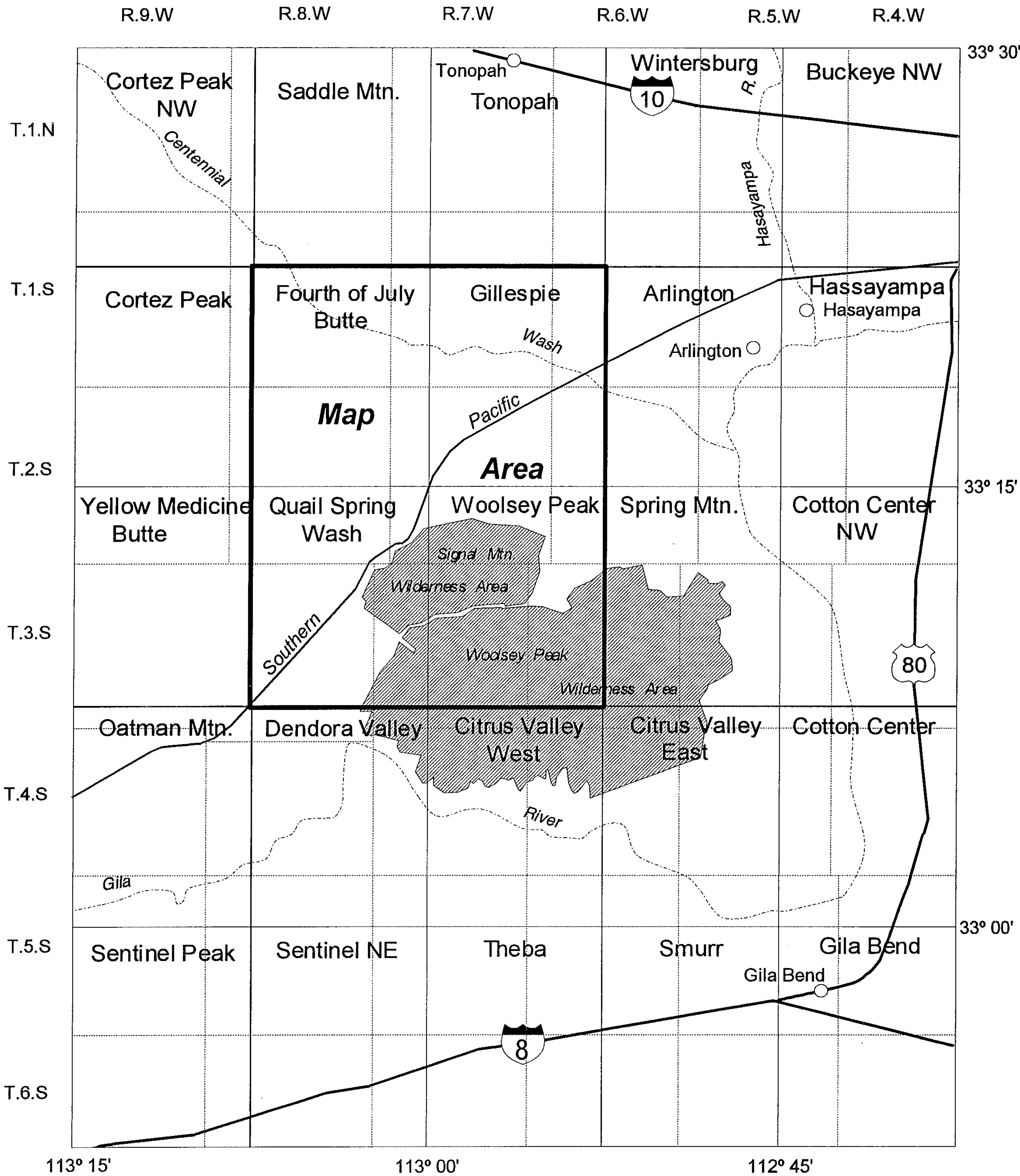


Figure 1. Location of study area, and names of U.S.G.S. 7.5' topographic quadrangles.

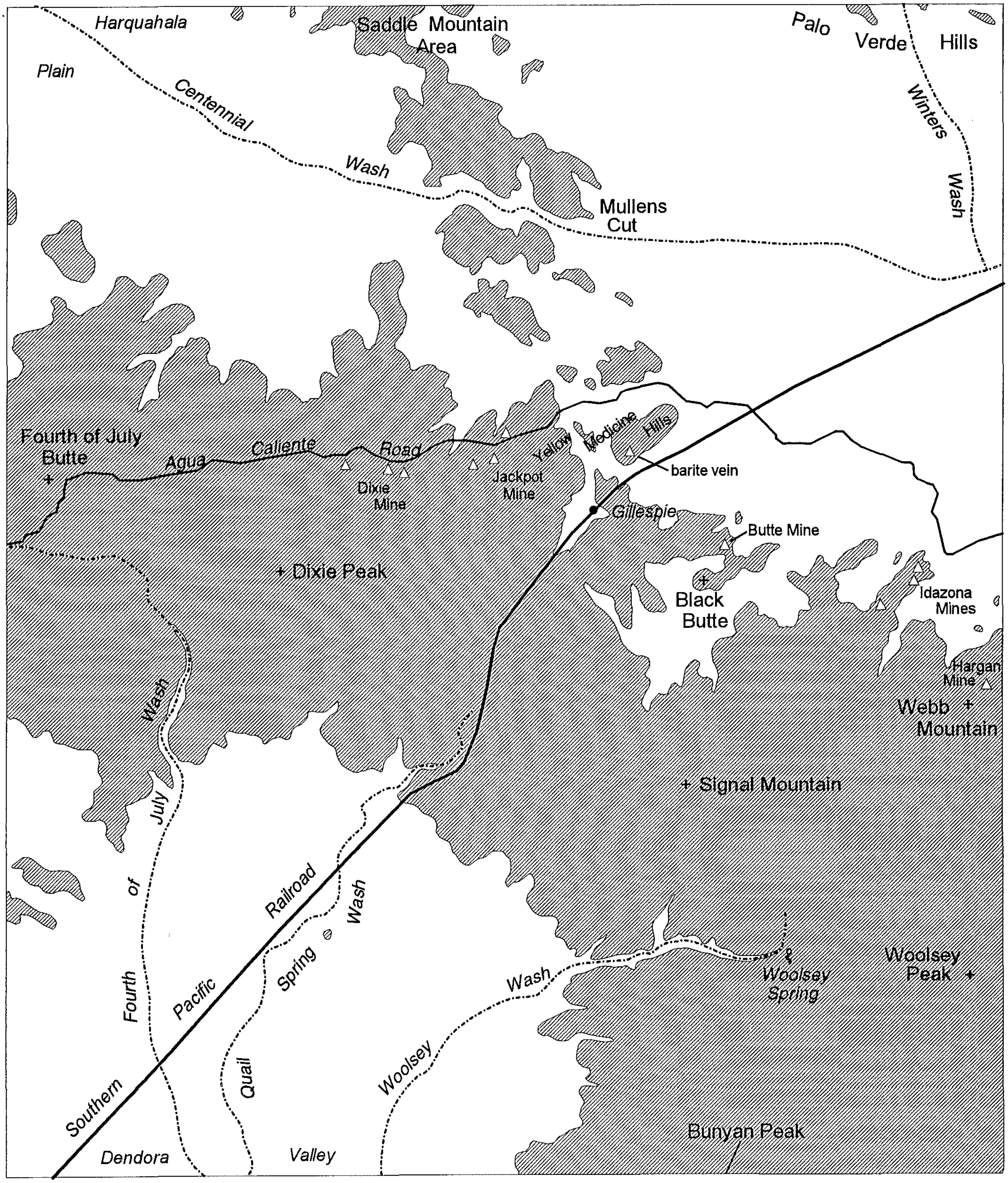


Figure 2. Place names and geographic locations.

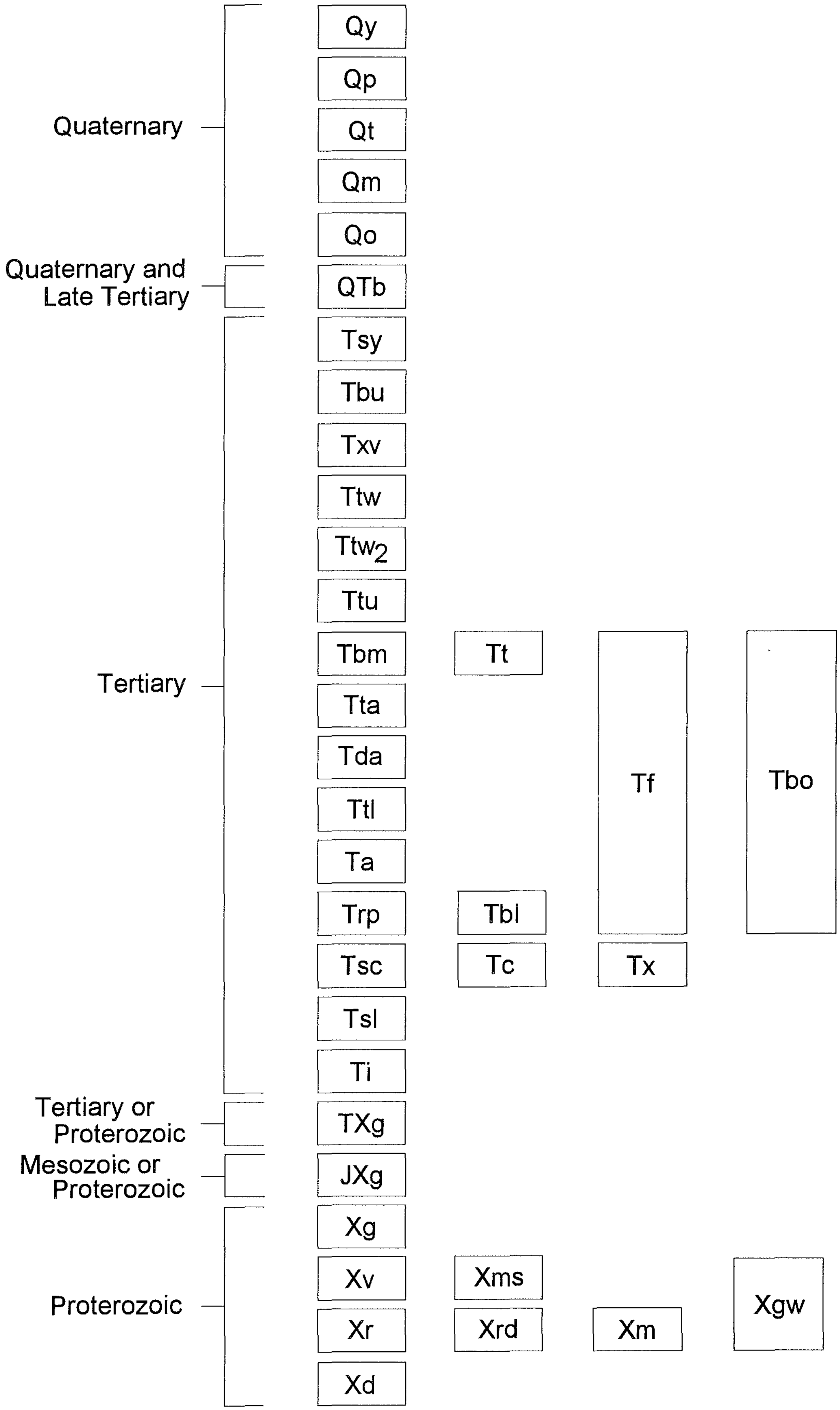


Figure 3. Correlation diagram for the central Gila Bend Mountains.

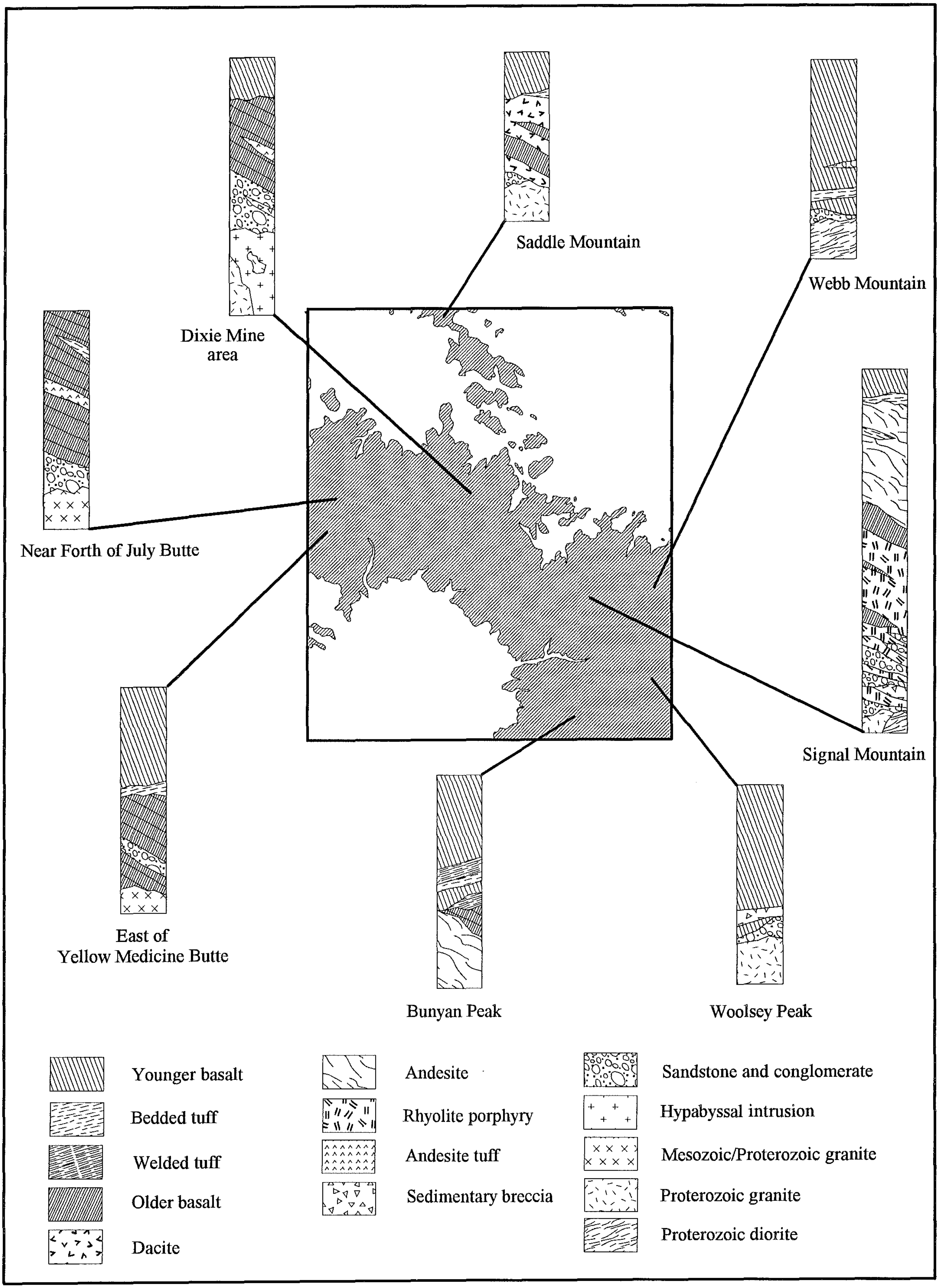


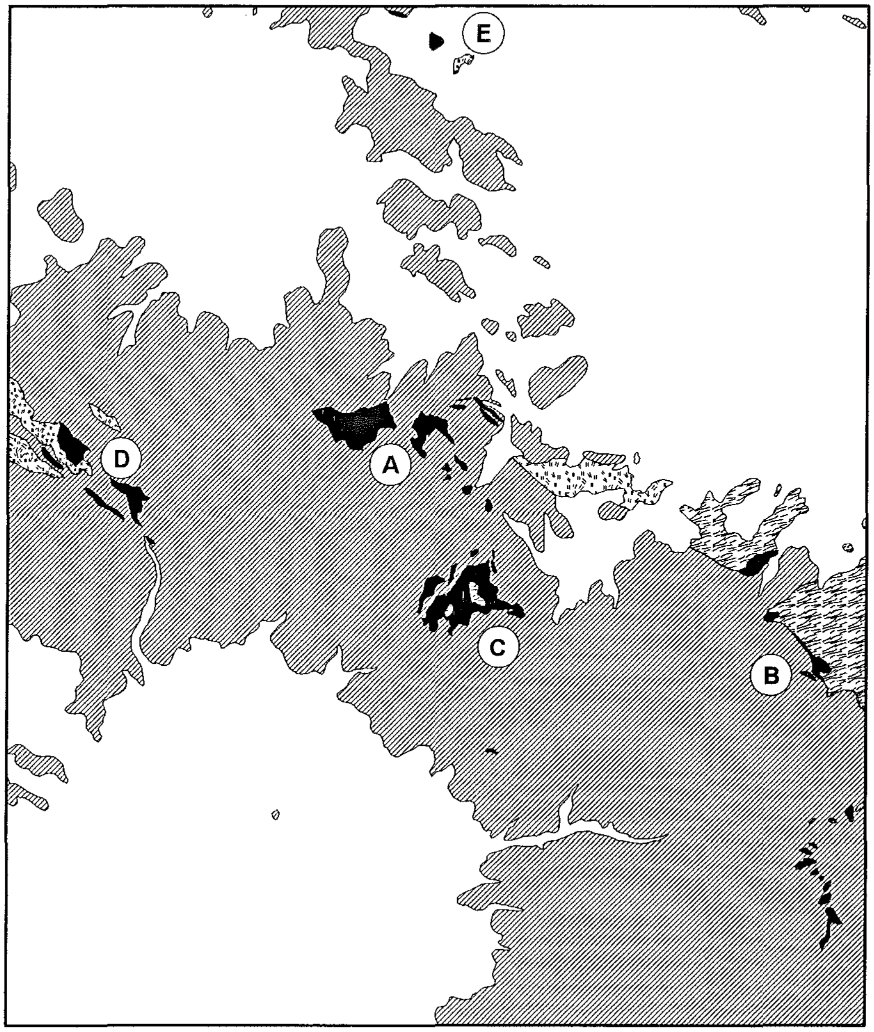
Figure 4. Selected stratigraphic sections.

Tertiary volcanic rocks

Sedimentary rocks

Proterozoic metamorphic rocks

Granitic rocks



Ⓐ Dixie Mine area
- Granite
- Granodiorite
- Schistose diabase
- Quartz-muscovite schist
- Quartz-biotite schist
- Rare volcanic rocks

Ⓑ Webb Mountain
- Chlorite schist/phyllite
- Dark grey schist/phyllite
- Metarhyolite
- Foliated green diorite
- Biotite granite
- Purple quartzite
- Banded iron formation
- Muscovite schist
- Rare basalt

Ⓒ Signal Mountain area
- Red-stained quartzite
- Banded iron formation
- Clear grey vein quartz
- Metarhyolite
- Grey sandy phyllite
- Fine-grained, non-foliated, muscovite granite with clear quartz, locally porphyritic
- Purple quartzite
- Dark green diorite
- Foliated biotite granite/granodiorite
- Grey and green slate/phyllite, locally crenulated
- Flattened quartz-jasper pebble conglomerate
- Brown and grey quartzites
- Rare basalt

Ⓓ Fourth of July Butte area
- Granodiorite gneiss
- Metarhyolite
- Green slate/phyllite
- Banded iron formation
- Fine- to medium-grained biotite granite
- Greenish grey biotite-chlorite schist
- Dark grey-green amphibolite/gabbro
- Brown and tan quartzite
- Medium- to coarse-grained biotite granite

Ⓔ Saddle Mountain area
- Coarse-grained, non-foliated, light grey, hornblende quartz monzonite
- Medium-grained red granite
- Green phyllite/schist
- Grey slate/phyllite
- Foliated biotite granodiorite
- Coarse-grained, red, porphyritic, foliated biotite (now chlorite) granite
- Rare basalt

Figure 5. Clast compositions of sedimentary rocks in the central Gila Bend Mountains.

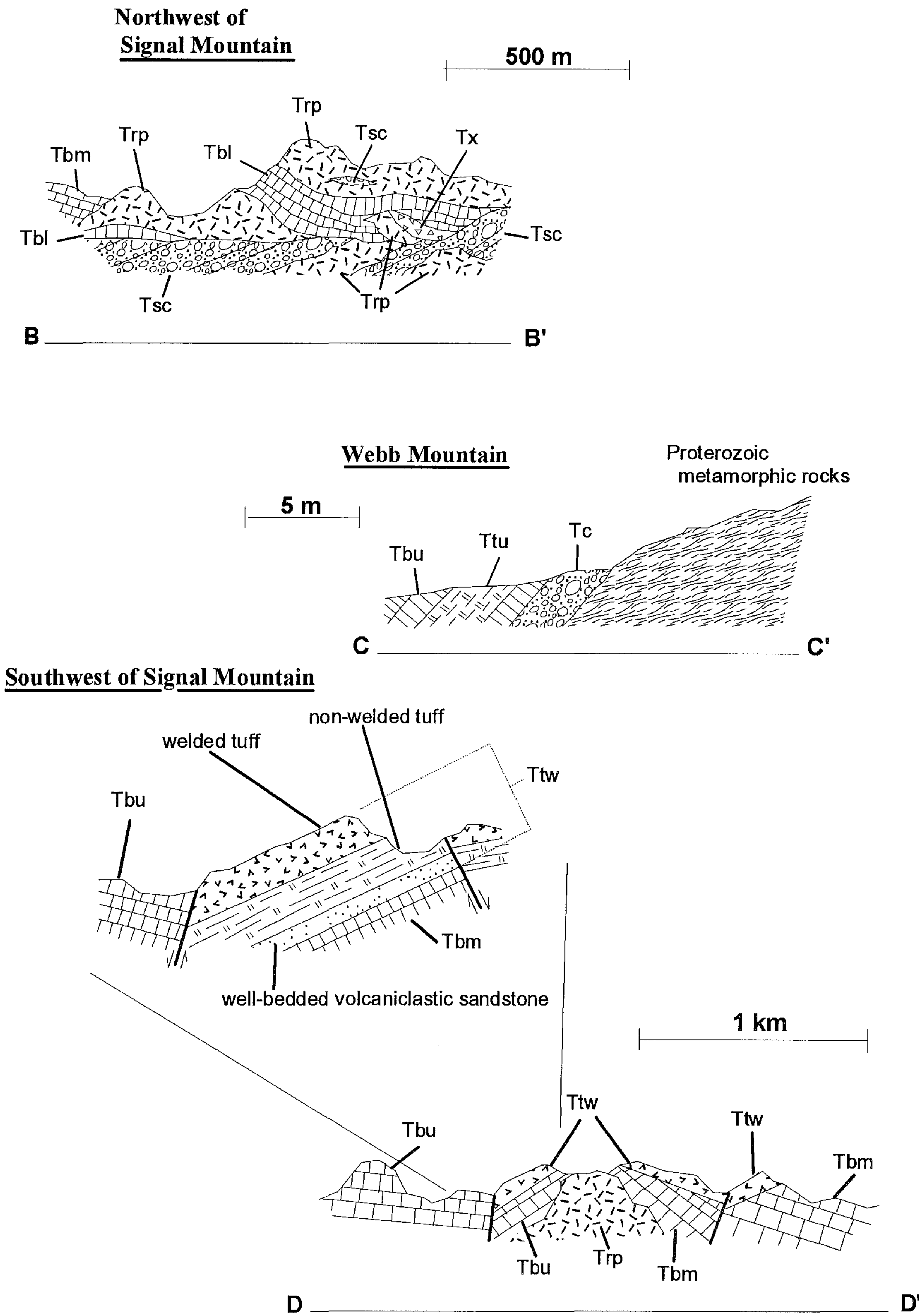


Figure 6. Selected diagramatic cross-setions. Not to scale.