GEOLOGIC MAP OF THE MIDDLE WATER SPRING 7 ½' QUADRANGLE, MOHAVE COUNTY, ARIZONA

Arizona Geological Survey Digital Geologic Map DGM-96, version 1.0
Scale 1:24,000

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October 2012

Citation for this map:
Johnson, Bradford J., Pearthree, Philip A., and Ferguson, Charles A., 2012, Geologic map of the Middle Water Spring 7 ½' Quadrangle, version 1.0, Mohave County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-96, scale 1:24,000.

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Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G10AC00428. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Bedrock Map Unit Descriptions

The following units and descriptions are based strictly on our mapping, and no attempt is made here to reconcile any observations or interpretations that differ from those of previous workers.

Bedrock Units

Supracrustal Units

Tc — **Volcaniclastic conglomerate (Miocene)** - Conglomerate, pebby sandstone, and sandstone containing clasts of rhyolite, dacite, and andesite. Generally medium- to thick-bedded and mostly clast-supported, although some thick massive units are matrix-supported. Sandy matrix is generally reddish, and non-volcanic clasts are conspicuously absent.

Tr — **Rhyolite (Miocene)** - Phenocryst-poor rhyolite lava and tuff undifferentiated, including up to 30% volcaniclastic conglomerate. Clasts in the conglomerate are dominantly rhyolitic, but also include, dacite, andesite, and basalt.

Tau — **Upper andesite (Miocene)** - Phenocryst-poor andesite containing <5% 1-2mm plagioclase, and pyroxene.

Tb — **Basalt (Miocene)** - Basalt lava including minor undifferentiated interbeds of basaltic scoria, tephra, and volcaniclastic rocks. Basalt lava contains 2-10% phenocrysts of olivine, pyroxene, and plagioclase.

Ta — **Andesite (Miocene)** - Andesitic lava with minor undifferentiated pyroclastic and volcaniclastic interbeds. Lava contains up to 15% phenocrysts of plagioclase <4mm, and lesser <2mm pyroxene, and olivine.

Tax — **Phenocryst-rich andesite (Miocene)** - Andesitic lava containing 5-25% phenocrysts of plagioclase up to 8mm, and lesser, altered mafics, probably pyroxene <4mm. This unit occurs interbedded with the volcaniclastic conglomerate (Tc)

Tfl — **Felsic pyroclastic and volcaniclastic rocks (Miocene)** - medium- to thick-bedded conglomeratic volcaniclastic rocks and felsic, nonwelded tuff. Clasts are dominantly dacitic and rhyolitic (phenocryst-poor and phenocryst-rich volcanics with biotite phenocrysts). Andesitic, mafic, and non-volcanic clasts are rare to absent.

Td — **Dacite (Miocene)** - Dacitic lava, tuff, and breccia containing 10-35% phenocrysts of plagioclase (1-8mm), biotite (<4mm), and/or hornblende (<4mm), and/or pyroxene (<2mm).

Tps — **Peach Springs Tuff (Miocene)** - Ignimbrite containing 15% phenocrysts of K-feldspar (<6mm) > plagioclase (<3mm), and < 1% biotite. Pumice, up to 20cm, make up 10% of the rock.

Tak — **Arkosic sedimentary rocks (Miocene)** - Arkosic sandstone, pebbly sandstone, and conglomerate containing clasts of plutonic and metamorphic rocks; volcanic clasts conspicuously absent.

Intrusive units

Tdc — **Basaltic dikes (Miocene)** - Mafic dikes containing sparse phenocrysts of olivine, pyroxene, and plagioclase

Tdb (dike) — **Diabase and gabbro dikes (Miocene)** - **Diabase and gabbro dikes (Miocene)** – Dikes ranging from fine-grained diabase to medium-grained gabbro. Diabase dikes are generally <10 m thick and display subophitic texture. Near the margins, many dikes grade to aphanitic with phenocrysts or glomerocrysts of plagioclase 1-8 mm long. Phenocrysts of augite up to 5 mm long are common near the margins, and in the interiors of some dikes. Medium-grained, equigranular gabbro forms the larger dikes of this suite, 10-50 m thick. These are composed of 40-50% clinopyroxene (augite), 50-60% plagioclase, trace magnetite, and trace to 1% sphene. Near their tips, thick gabbro dikes grade along strike to thin diabase dikes, in some cases terminating in horsetail splays.

Tpa (dike) — **Aplitic porphyry dikes (Miocene)** - Porphyry dikes containing 2-10% K-feldspar phenocrysts (2-4 mm, euhedral, commonly Carlsbad-twinned), 0-10% quartz phenocrysts, 0-10% mafic phenocrysts (equant, anhedral to subhedral), and trace to 1% biotite (up to 2 mm) in a white to light-gray, aplitic to aphanitic groundmass. Biotite and K-feldspar are locally altered, imparting a rusty-yellow color to some dikes.

Tpg (dike) — **Granitic porphyry dikes (Miocene)** - Porphyry dikes containing K-feldspar phenocrysts up to 1 cm, 1-2% quartz phenocrysts, and <5% fine-grained mafic minerals in an aplite groundmass, weathered rusty yellow. Mineralogically, these dikes resemble rocks within the porphyritic marginal phase of unit Tgg monzogranite.

Tpz (dike) — **Zoned composite dikes and related felsic porphyry dikes (Miocene)** - Dikes composed of felsic porphyritic interior zones and mafic marginal zones. Interior zones are light-gray and fine-grained, with typically sparse (2-10%) feldspar phenocrysts 3-10 mm long (up to 20 mm in some dikes) and 2-15% mafic minerals. Mafic minerals include fine-grained biotite (typically chloritized, mostly <1 mm, locally up to 2 mm) and, in some dikes, hornblende or pyroxene up to 5 mm long. The feldspars include tabular, euhedral, light-gray to pink, Carlsbad-twinned K-feldspar and tabular to ovoid, euhedral to subhedral, commonly zoned, generally altered (sericitized); white to light-gray plagioclase. Some feldspar phenocrysts, especially larger ovoid ones, consist of K-feldspar cores mantled by plagioclase rims (rapakivi texture). Some dikes contain up to 1% 1-mm quartz phenocrysts, and most have sparse mafic inclusions up to several cm across. The inclusions are fine-grained, gray, and some contain the same phenocryst assemblage as the host porphyry. The marginal zones of Tpz dikes are fine-grained diabase, commonly containing sparse 2-4 mm phenocrysts of plagioclase and pyroxene. Contacts between the interior and marginal zones range from sharp to gradational over a few m, but are most commonly gradational over a few cm, suggesting that the mafic marginal zone and felsic interior zone magmas were emplaced nearly simultaneously. Along strike, some dikes grade to either felsic porphyry or diabase without the zoned composite character. While they are different from other dikes in the map area, there is variation among dikes mapped as Tpz, and not all are necessarily cogenetic. Moreover, some of the dikes resemble other plutonic units in the area and may be cogenetic with those other units. For example, the interiors of some dikes are identical to quartz monzodiorite in the upper part of unit Tg, dikes that contain zoned (rapakivi) feldspar phenocrysts are likely related to unit Tgp, and the mafic marginal zones resemble diabase of unit Tdb.

Tgg — **Coarse-grained leucocratic monzogranite (Miocene)** - Medium- to coarse-grained (5-8 mm), equigranular monzogranite containing <5% biotite. Near intrusive contacts with country-rock gneiss, equigranular granite grades to phenocryst-rich quartz-feldspar porphyry with hardly any biotite, and with aplite and small pegmatitic quartz segregations locally. The porphyry phase contains phenocrysts of K-feldspar (typically 2-8 mm, locally up to 2 cm) and quartz (1-4 mm), and its contacts with the coarse-grained granite are sharp to gradational over up to 5 cm. Where contacts are sharp, porphyry has intruded the coarse-grained granite.

Tpp — **Porphyritic granitic rocks (Miocene)** - Porphyritic leucogranite and variably biotite-phyric granitic rocks containing 10-15% feldspar phenocrysts (1-3 mm; mostly plagioclase) and up to 5% quartz phenocrysts (less than 2 mm) in a fine-grained groundmass.

Tgp — **Porphyritic biotite granite (Miocene)** - Medium-grained, porphyritic monzogranite to granodiorite, containing 10-20% biotite and up to 15% phenocrysts of K-feldspar (5-25 mm) and plagioclase (4-8 mm). The K-feldspar phenocrysts typically display Carlsbad twinning and some have rims of white plagioclase <2 mm thick (rapakivi texture).

Mount Perkins pluton

Tg (dike) — **Granite, granodiorite (Miocene)** - Biotite monzogranite to granodiorite composed of medium- to fine-grained K-feldspar (commonly 2-5 mm, locally up to 1 cm), fine- to medium-grained plagioclase, fine-grained quartz, and 3-10% fine-grained biotite. The unit includes some quartz monzonite and quartz monzodiorite, especially in the upper 400 m of the pluton where fine-grained quartz monzodiorite containing 12-15% biotite (commonly chloritized) forms a locally distinct belt of spheroidally weathered outcrop, but grades laterally into granodiorite with less biotite and more resistant outcrop. Granite and granodiorite near the roof of the pluton commonly is composed of euhedral 2-5-mm K-feldspar and plagioclase, anhedral quartz (mostly 1 mm and less), 1-2% biotite, and interstitial, fine-grained, quartzofeldspathic groundmass that forms <50% of the rock. Aplite and minor local pegmatite segregations occur within this zone.

Tgi — **Granite and granodiorite with mafic inclusions (Miocene)** - Medium-grained monzogranite to granodiorite containing 2-15% fine-grained biotite and 5-50% pillow-like inclusions of dark gray, fine-grained to aphanitic mafic rock. The granite to granodiorite host locally grades into, and in other places has been intruded by, granite and granodiorite of unit Tg. The mafic inclusions mostly appear to be hornblende diorite, and some contain biotite. Most of them are a few cm to 1 m across, but they range up to several m long. Many of the inclusions have crenulate, sharp, chilled margins, notably darker and finer-grained than the interiors. Some inclusions contain quartzofeldspathic amygdules, which form individual and coalesced spheroids ranging from a few mm to a few cm across. Amygdules are most common in aphanitic inclusions with crenulate, chilled margins. In addition to the pillow-like inclusions, which are interpreted as having formed from mafic magma emplaced into still-molten or only partially crystallized granite-granodiorite host, unit Tgi also contains xenoliths of gabbro, quartz diorite, and gneiss. Field relationships clearly indicate that the gabbro and quartz diorite xenoliths were derived from units Tgb and Tqd and the gneiss was derived from Paleoproterozoic units.

Tgis — **Granodiorite with sparse mafic inclusions (Miocene)** - Fine- to medium-grained biotite granodiorite to monzogranite containing sparse (<5%) pillow-like inclusions of dark gray, fine-grained to aphanitic mafic rock, generally <15 cm across. The granodiorite is typically fine-grained with 15-20% medium-grained (2-6 mm) K-feldspar phenocrysts. This unit grades into more inclusion-rich unit Tgi. Contacts with medium-grained monzogranite of unit Tg are locally distinct, but feldspars cross the contact and the K-feldspar phenocrysts in the fine-grained porphyritic phase look identical to those throughout the medium-grained monzogranite.

Tgm — **Granodiorite with >50% mafic inclusions (Miocene)** - Fine- to medium-grained biotite granodiorite to monzogranite containing 50-80% pillow-like inclusions of dark gray, fine-grained to aphanitic mafic rock. The inclusions display the same characteristics as those described for unit Tgi, and this unit grades into unit Tgi. The granitic host, which typically contains 15-20% biotite, locally grades into, and in other places has been intruded by, granite and granodiorite of unit Tg.

Tqd — **Quartz diorite, diorite, granodiorite (Miocene)** - Suite of mesocratic plutonic rocks, consisting predominantly of fine- to medium-grained quartz diorite, with less abundant granodiorite (or tonalite) and diorite. Quartz diorite contains 30-50% mafic minerals, including biotite (5-20%) and either hornblende or clinopyroxene (or both). Traces of sphene are common. Granodiorite is typically fine-grained and contains 20-30% mafic minerals of the same assemblage. Diorite contains no more than 5% biotite, some of which appears to form reaction rims on faces of clinopyroxene. Rocks of this suite are light to medium gray, and the biotite-rich phases form brown-weathered, rounded outcrops. In some places, unit Tqd exhibits commingled contacts between medium-grained and fine-grained phases of the suite. The fine-grained phase generally appears to be more quartz-rich (granodiorite or tonalite) and appears to have intruded the medium-grained phase. Unit Tqd also contains some medium-grained quartz monzodiorite or quartz monzonite, which locally contains fine-grained mafic inclusions (diorite?) and locally has intruded medium-grained quartz diorite and diorite. Variation among rocks of the suite is inferred to reflect different degrees of hybridization between granitic and mafic magmas. All rocks of the Tqd suite have locally been intruded by fine- to medium-grained leucocratic granite or granodiorite of unit Tg.

Tgb — **Gabbro (Miocene)** - Medium- to coarse-grained gabbro composed of 50-60% plagioclase and 40-50% clinopyroxene (augite?). Coarse-grained gabbro is commonly poikilitic, with oikocrysts of clinopyroxene up to 4 cm enclosing plagioclase. Fine- to medium-grained leucogabbro containing <25% clinopyroxene is locally present but uncommon.

Tog — **Olivine gabbro (Miocene)** - Medium-grained, equigranular to poikilitic, rusty brown-weathered olivine gabbro. Olivine throughout the unit has been replaced by serpentine pseudomorphs. Where the texture is poikilitic, oikocrysts of clinopyroxene enclose cumulus grains of plagioclase and serpentinized olivine. Parts of this unit display cumulate layering.

Tom — **Olivine gabbro, melanocratic, poikilitic (Miocene)** - Medium- to coarse-grained, poikilitic olivine melagabbro, composed of 20-50% cumulus olivine pseudomorphs (replaced by orange-brown-weathered black serpentine), 40-60% cumulus and postcumulus clinopyroxene (cumulus crystals and oikocrysts), and 10-35% plagioclase (nearly all of which is intercumulus). Clinopyroxene oikocrysts up to 5 cm across enclose cumulus olivine pseudomorphs. Magnetite also is present (several percent) either as a cumulus phase or as another replacement product of olivine. Rocks of this unit are hard, dense, dark green-gray, and weathered dark brown to black. Cumulate layering is evident on weathered surfaces.

TXg — **Biotite granite dikes (Tertiary - Paleoproterozoic)** - Fine-grained, equigranular, granite or granodiorite dikes containing 10-15% biotite. These dikes locally exhibit a weak to moderate foliation defined by aligned biotite, and they have been intruded by pegmatite dikes.

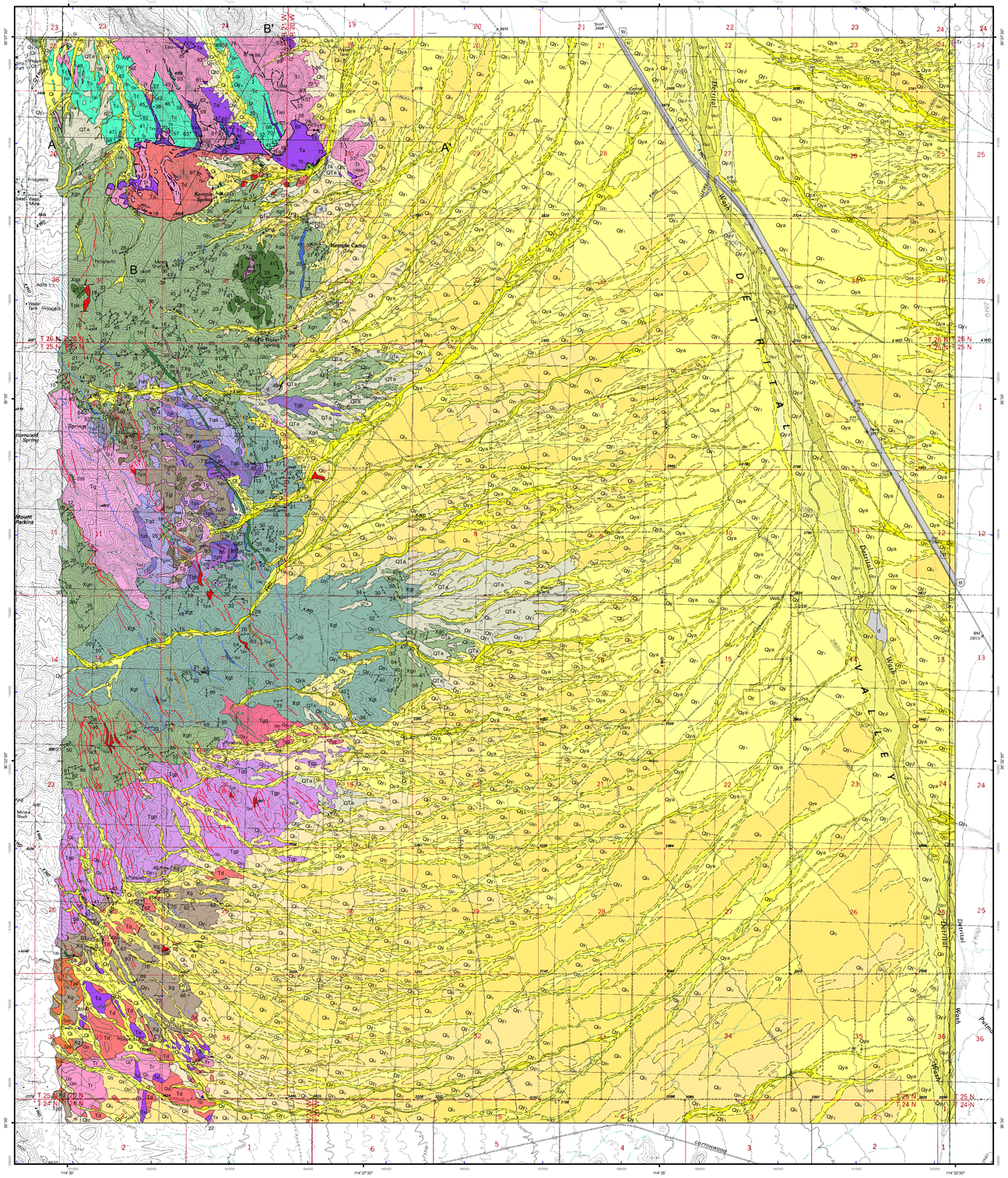
Metamorphic units

Xgt — **Tonalitic gneiss (Paleoproterozoic)** - Foliated to gneissic granitoid ranging from tonalite to diorite in composition, commonly with thin amphibolite or hornblendite layers and local pegmatite. The granitoid is mostly fine- to medium-grained tonalitic gneiss containing 25-40% biotite and hornblende in variable proportions. The amphibolite layers range from a few mm to a few m thick but are typically <30 cm thick. In the southeastern part of this unit, coarse-grained biotite tonalite to granodiorite is the predominant rock type.

Xg — **Biotite granite gneiss (Paleoproterozoic)** - Medium- to coarse-grained, feldspar porphyritic granite containing 15-30% chloritic biotite. The granite is typically strongly to moderately foliated; the texture is typically recrystallized mylonitic fabric.

Xga — **Amphibolite (Paleoproterozoic)** - Amphibolite, locally interfoliated with quartzofeldspathic paragneiss, granitoid gneiss, fine-grained biotite-quartz-feldspar gneiss, and pegmatite. Discordant pegmatite is also present.

Xgn — **Heterogeneous gneiss (Paleoproterozoic)** - Heterogeneous granitoid gneiss, paragneiss, amphibolite, and pegmatite. Most of this unit is granitoid gneiss, in layers a few cm to several m thick, with interfoliated biotite-rich paragneiss layers a few mm to a few cm thick. Many of the biotite-rich layers contain garnet porphyroblasts, or pseudomorphs of garnet porphyroblasts, locally up to 2 cm (they appear to be composed of fine-grained biotite, quartz, and relict garnet). Garnet porphyroblasts also occur in granitoid gneiss adjacent to paragneiss layers. Other rocks in this unit include amphibolite, fine-grained biotite-quartz-feldspar gneiss, quartzofeldspathic paragneiss, and rare epidote calcisilicate and quartzite. Leucogranite and pegmatite are locally interfoliated, locally discordant.


114°30'
114°27'30"
114°25'
114°22'30"
35°15'30"
35°10'
35°05'
Mount Perkins
Kempton Camp
Middle Water Spring
Detrital Wash
Detrital Valley
Mohave Wash
Paiute Wash
Cottonwood
Hackberry Wash
Stockton Wash
Hualapai Valley
Ferguson Wash
Hackberry
Stockton Hill
Cerbat Mts
Hualapai Mts
Pine Mtn
Mt Tipton
Hackberry Mtn
Mt Nutter
Mt Wallace
Mt Hope
Mt Tom
Mt Dellenbaugh
Mt Bradley
Mt Ashley
Mt Stevenson
Mt Hayden
Mt Cleveland
Mt Powell
Mt Emma
Mt Gordon
Mt Wilson
Mt Sherman
Mt Tyndall
Mt Newberry
Mt Trumbull
Mt Logan