GEOLOGIC MAP OF THE FORTIFIED PEAK 7½' QUADRANGLE, SOUTHEASTERN PINAL COUNTY, ARIZONA

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Arizona Geological Survey Digital Geologic Map 18, version 2.0

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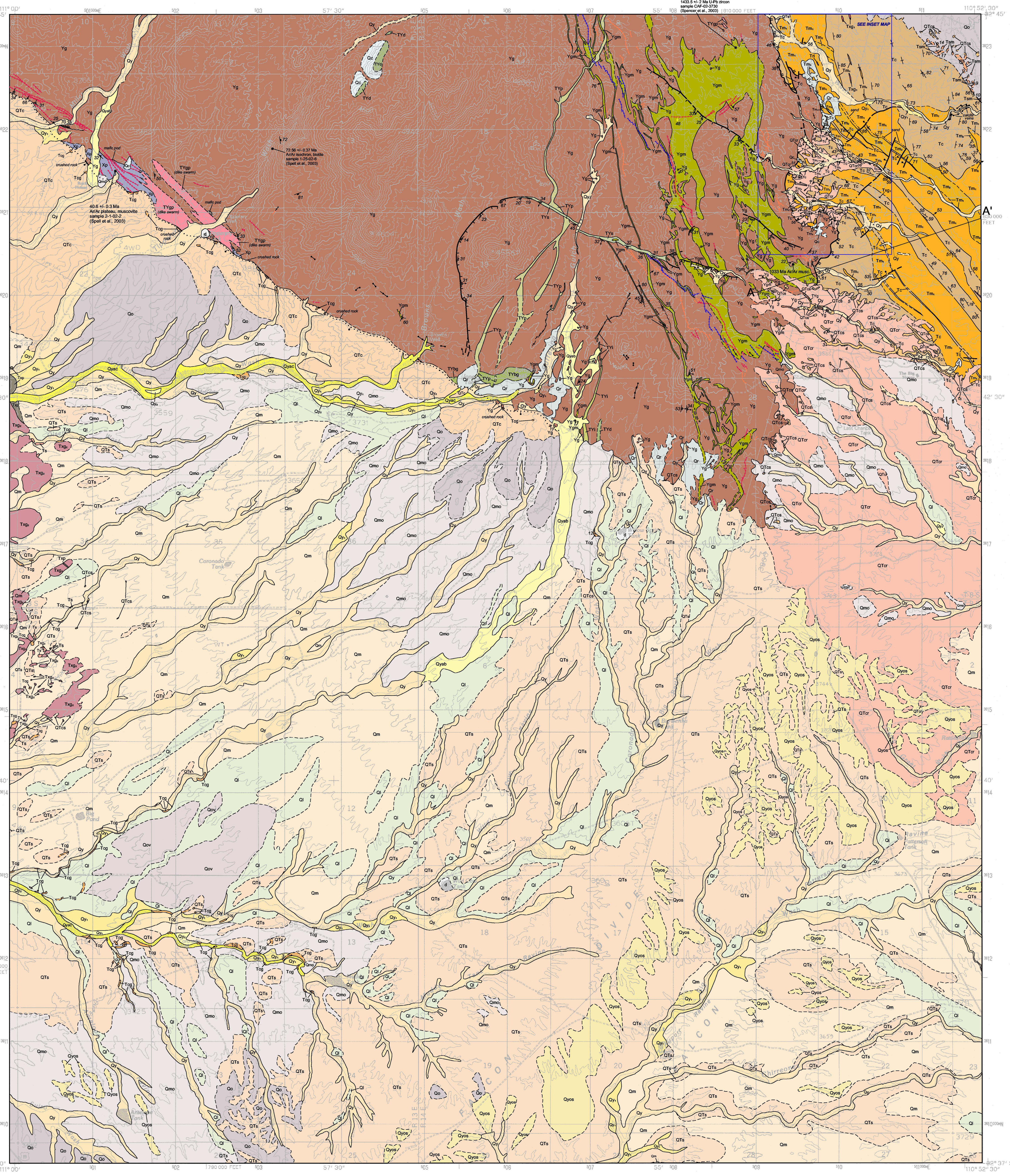

Topographic base from USGS Fortified Peak 7½' quadrangle, Transverse Mercator projection, UTM grid, zone 12, 1927 North American Datum.

SCALE 1:24,000

CONTOUR INTERVAL 40 FEET

INTRODUCTION

This report and accompanying map detail the bedrock geology, structural geology, surficial geology, geomorphology, and geologic hazards of the Fortified Peak 7½' quadrangle, which is located north of Oracle Junction along the Falcon Divide separating the San Pedro River watershed from the Canada del Oro watershed in Pinal County, Arizona. The northern part of the quadrangle includes the southern portion of the Black Mountains, a dominantly granitic bedrock highland of about 30-square miles that consists of small, rugged peaks with elevations up to about 5,600 feet. The southern two-thirds of the quadrangle encompasses a broad, low-relief piedmont of eroded Tertiary basin-filling sediments mantled by Quaternary alluvial materials of variable age. Urbanization has not occurred in this area as of publication, but proposed housing development exemplifies the need to understand the geologic setting and potential hazards of the Fortified Peak quadrangle.

Bedrock and surficial geology in the study area were mapped between October 2001 to June 2002 as part of a multiyear mapping program directed at producing complete geologic map coverage for the Phoenix-Tucson metropolitan corridor. The primary product resulting from new mapping in the study area is a 1:24,000-scale geologic map. This accompanying report describes rock units and other geologic features. The mapping was done under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992, and was jointly funded by the Arizona Geologic Survey and the U.S. Geological Survey under STATEMAP Program Contract #01HQAG0098.

This map version (v. 2.0) includes new mapping by J. Spencer where the inset map (see below) extends onto the adjacent Black Mountain 7½' quadrangle, a cross-section, and new geochronologic information, all of which were not included on the original map version. Because new mapping has been added, the date of publication has also been updated for this map.

Previous geologic mapping in the Fortified Peak 7½' quadrangle is limited to reconnaissance mapping in the Star Flat/Willow Springs area in the northeast part of the map area by Dickinson (1994), who determined the basic structural and stratigraphic framework of the pre-Quaternary map units and outlined the structural significance of the Star Flat detachment fault (Dickinson, 1991).

ACKNOWLEDGMENTS

Willow Springs Ranch granted permission to access private lands. Falcon Valley Ranch provided access through locked gates on leased state trust land. P. Pearthree and A. Youberg provided valuable discussions and guidance related to the surficial geology of the area. L. Fellows is acknowledged for ongoing support of geologic mapping in Arizona.

METHODS

The bedrock geology was mapped and described by T. Orr, J. Spencer, and S. Richard. T. Orr prepared map version 1.0; E. Moore prepared version 2.0. S. DeLong mapped and described Quaternary surficial units. Bedrock geology was mapped by direct field interpretation. Quaternary and late Tertiary sediments were mapped by direct field observation and aerial stereo-photo interpretation. USGS 1:30,000-scale color aerial photographs from 1983 were used in this study.

The physical characteristics of Quaternary depositional surfaces were used to assign ages to specific deposits. Alluvial deposits of similar age tend to have similar physical characteristics and can be correlated with a reasonable degree of certainty. Relative relief, degree of erosion and dissection of the original depositional topography, and soil development are all indicators of age. Soils in particular show systematic development of several characteristics with age (Birkeland, 1999; Gile and others, 1981). Soil color tends to change from the color of the originally deposited material (alluvial fan and stream sediment). Initially the soil turns to dark brown with the progressive addition of organic material and wind-borne dust and then progresses to red with accumulation of iron oxides and weathering of clay minerals. Holocene surfaces tend to be brown, late Pleistocene surfaces tend to be light red, and early Pleistocene surfaces tend to be a deep red. Clay enrichment also progresses with time due to addition of wind-borne materials and chemical weathering of primary sedimentary material; this affects the consistency and structure of the soil. Older deposits tend to be enriched with clays to a greater degree and depth than younger materials. In semi-arid climates carbonate accumulates at depth within the soils. The amount of carbonate accumulated in semi-arid soils is also a useful indicator of relative age of the surface materials.

CLIMATE

The climate of the map area is hot and semi-arid. Summer temperatures are extremely hot, and precipitation occurs in two distinct seasons, as winter rains and as afternoon monsoon storms in the late summer months. The Willow Springs Ranch weather station is located in the northeastern part of the map area at an elevation of 3,690 feet, and recorded weather information from 1949 to 1978 (WRCC web site). Mean annual precipitation is 15.1 inches and the mean annual high temperature is 77.1° F with an average July high temperature of 95.4° F. The mean annual low temperature is 47.5° F with the average January low temperature of 31.8° F. Precipitation and temperature varies with elevation and proximity to mountains. 6 miles SE of this map area is the Oracle weather station at an elevation of 4,600 feet. At Oracle the mean annual precipitation is 19.40 inches and the mean annual high and low temperatures are 74.6° F and 49.9° F, respectively. This area is located in the Sonoran Desert upland, in a mix of desert and grassland vegetation.

GEOLOGIC HAZARDS

Geologic hazards present in southern Arizona include floods, gully formation, debris flows, rockfall, and earth fissures related to subsidence. Following is a brief and general discussion of the potential for these hazards in the Fortified Peak quadrangle. This is not intended to replace detailed site-specific geologic, engineering, hydrologic or soils investigations.

Intense late summer, early fall and winter rains can produce dramatic floods in this area. Incised stream valleys and steep riverbanks are susceptible to erosion during the largest of these events and overbank flooding can pose a hazard to nearby development. Most channels in this area tend to be fairly small, however Suffering Wash, Coronado Wash and Patterson Wash are three larger systems that drain the majority of the area. These larger washes are subject to lateral channel migration during large storm events, especially in low-relief areas, such as where bordered by younger alluvial materials. Diversion by humans and natural stream capture processes has left abandoned stream channels (Qyab) that also may be subject to flooding during large storm events. The young alluvial materials, such as Qy, Qy_1 and Qy_2, all represent areas that have undergone major flooding over the last 10,000 years or less. Particular attention must be paid to these areas when assessing flood potential.

Related to flooding is the formation of narrow, steep-sided, 1-8 m deep gullies in areas of concentrated water flow on various age alluvial surfaces. These gullies are present in close proximity to incised channels where stream incision is progressing headward into formerly stable alluvial surfaces, especially into Ql and Qm surfaces. These also seem to be associated with ranch roads, as wheel ruts concentrate flow allowing for dramatic erosion. Many under-developed roads are currently threatened and/or damaged by gully formation.

Debris flows are concentrated mixtures of poorly sorted sediment and water. Both debris flows and rockfalls are initiated on relatively steep slopes in mountainous areas. In this map area, loose material is generally removed from steep slopes before it accumulates to a hazardous level, however large boulders and blocks are common features of the landscape in the northern portion of the map area and testify to the possibility of this type of hazard. It is possible that an extreme rainfall could trigger a hazardous debris flow or rockfall, and this hazard should be considered if development is initiated near the mountains in the northern portion of the map area.

In Arizona, groundwater usage has led to localized land subsidence and earth fissures, costing millions of dollars in property damage. In this map area there is no evidence for this phenomenon, however if groundwater removal were to increase, the potential for problems would increase accordingly.

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GEOLOGIC MAP UNITS

Quaternary and late Tertiary map units

Unconsolidated deposits

Qy — Undifferentiated Holocene alluvium (0 to 10 ka)
This unit contains Qyac, Qy_2, and/or Qy_1 deposits where map scale does not allow for differentiation. Generally this unit is characterized by a <10 m wide incised channel flanked by Qy_2 and/or Qy_1 deposits less than 2 m high.

Qyc — Active channel deposits (< 1 ka)
Poorly to moderately-sorted, moderately rounded to subangular medium to coarse sand and gravel with occasional cobbles and boulders up to 1 m in diameter in active washes. This material is coarsest in high-gradient channels located close to the bedrock highland in the northern portion of the map area, and much finer (sand-dominated) in the larger higher-order streams in the south and central parts of the map area farther from the bedrock highlands. This unit occasionally includes vegetated areas on <1 m high channel bars on the largest streams in the map area. Vegetation on bars is dominantly palo verde and mesquite. These bars are subject to flooding as evidenced by flotsam, minimal soil development and sand and gravel splays. Most channels in this area are entrenched below Holocene and older terraces at least 0.5 m and up to 10 m in older sediments.

Qy_2 — Late Holocene alluvium (< 2 ka)
Qy_2 deposits are recent alluvium that shows evidence of intermittent inundation only during large flood events. The surface of this unit is usually <1 m above the active channel. Material is moderately sorted and sub-rounded to sub-angular sand, gravel, cobbles and occasional <1 m diameter boulders. Soil development is limited to weak structure and a slight brownish color. These deposits generally have well-established vegetation including grasses, yucca, mesquite, palo verde, acacia and other shrubs. Evidence of occasional flooding includes flotsam, sand and gravel outburst splays and incision by distributary channels and channel braids. Morphology of this unit is low-relief, with sub-meter scale bar-and-swale topography common.

Qy_1 — Holocene alluvium (~2 to 10 ka)
Qy1 deposits consist of 0.5 m to 2 m fluvial terraces preserved along the flanks of most fan channels. Materials in this unit tend to be moderately sorted sub-angular to sub-rounded sand and gravel with minor boulders and cobbles up to 1 m in diameter. The surfaces of this unit are generally planar, dark brown and sandy, with a sparse, light-colored gravel lag. Material coarser than gravel is uncommon on these surfaces. Soil development is weak to moderate, with moderately hard subangular blocky structure, an accumulation of finer materials sufficient to erase most original sedimentary structure, and variable amounts of stage I-II pedogenic carbonate in the forms of filaments to discontinuous clast coatings present below 70 cm. These terraces support sparse vegetation including mesquite, yucca, prickly pear, barrel cacti, cholla, grasses and shrubs.

Qyab — Holocene alluvium associated with partially abandoned channels (0 to 10 ka)
Abandoned or "underfit" channels and low terraces associated with modern channels much smaller than predicted by the size of valley. These are most pronounced near bedrock highlands in the northern part of the quadrangle where stream capture appears to have occurred as drainage shifted from southward to westward during Holocene time. Several smaller streams have been abandoned due to anthropogenic diversion for the purpose of cattle ranching. These deposits have higher vegetation density than do Qyac deposits. These channels could be active as flood spillways during large flood events.

Qyos — Holocene organic-rich sediment (0 to 10 ka)
Dark brown to black 1 to 3(?) m thick Holocene sediment and soil located in swales in low relief areas near non-incised 1st and 2nd order streams. This unit mantles older units, especially low-relief areas of eroded QTs on or near the Falcon Divide, but also mantles swale areas of middle and older Pleistocene deposits in the southern portion of the map area. Qyos deposits are likely evidence of past presence of wetland-type "cienega" grassy vegetation in these areas. Currently these areas are mostly devegetated and are being degraded by slope wash and incipient incision.

Ql — Late Pleistocene alluvium (~10 to ~130 ka)
Ql deposits consist of alluvium with sub-rounded to sub-angular cobbles deposited during times of alluvial fan aggradation. This unit consists of planar to highly-dissected fan channel terrace remnants. These remnants tend to be 10s of meters across and flank modern channels at a height of 3-6 m. They are easily distinguished by their orange-red color, dominantly planar sub-meter scale topography and tendency to be sharply intruded by vertical incision near their edges, especially when in close proximity to cutbanks along modern washes. Ql surfaces tend to have a sparse light-colored gravel lag with occasional concentrations of vein quartz and felsic volcanic cobbles, which are white but markedly reddened on their undersides reflecting the color of the underlying finer material. Soil development is moderate, with orange-red argillic sandy loam reaching the depth of most exposures. Pedogenic carbonate accumulation is moderate below 60 cm up to stage II. Vegetation on this unit includes sparse cholla, prickly pear, mesquite, barrel cacti, and yucca. This unit often lacks grass, which is common to other surfaces in this map area.

Qm — Middle Pleistocene alluvium (~130 to ~750 ka)
Qm deposits consist of alluvium with sub-rounded to sub-angular cobbles deposited during times of alluvial fan aggradation. These deposits are rounded ridges with well-preserved red planar surfaces in many areas. They tend to be between 4 and 10 m above modern stream channels and form large surfaces incised by multiple channels in the western and southeastern sections of the map area. These units are distinguished from Ql surfaces by more clay-enriched soils, stronger red color, higher position relative to the modern stream channels and a greater degree of incision. Qm surfaces tend to be fine-grained with occasional fine gravel lag and areas of quartz and volcanic cobble accumulation. Vegetation is occasionally very sparse, but is dominated mesquite, cholla, prickly pear, barrel cacti, yucca and grasses.

Qmo — Middle and early Pleistocene alluvium, undivided (~130 ka to ~2 Ma)
Qmo units are high fan terraces intermediate in elevation and relief between Qm and Qo units near the bedrock highlands in the northern portion of the map area and the southwestern portion of the map area, as well as high remnant surfaces of indeterminate age mantling older eroded QTs units. They tend to be have red, well-developed soils but are poorly exposed in this map area.

Qo — Early Pleistocene alluvium (~750 ka to ~2 Ma)
Qo units are the highest, reddest alluvial fan remnants in the map area. They appear as rounded, eroded ridges draped with well-developed soil and as preserved planar surfaces in the highest areas of the map area. These appear very coarse near the mountain front, having coarse granite boulder lag in places. This unit is poorly exposed beneath their rounded surfaces. In the southwest portion of the map area north of Coronado Wash, several patches of Qo are markedly brown in color due to a high concentration of volcanic clasts.

Qov — Early Pleistocene alluvium with volcanic clasts (~750 ka to ~2 Ma)
Qov units are equivalent to Qo units, but represent areas, as described above, with a high concentration of volcanic clasts that give the soils a distinct brown color.

Other Quaternary to late Tertiary Deposits

d — Disturbed areas (< 100 years)
Areas where human activity has obscured the underlying geology, primarily by excavation of earthen water tanks for cattle ranching.

Qr — Quaternary residuum (< 2 Ma)
Unconsolidated soil and weathering products formed in situ from parent materials including bedrock and colluvium. These units show only minor evidence of transport.

Qc — Talus and colluvium (< 2 Ma)
Unconsolidated to moderately consolidated colluvium and talus hillslope deposits found as a thin mantle on bedrock slopes. This unit is characterized by gravity-transported, unconsolidated regolith with subangular to angular, poorly sorted, sand- to boulder-sized clasts. Adjacent bedrock lithologies dominate the clast compositions. These deposits probably range in age from Holocene to middle Pleistocene.

QTc — Early Pleistocene to Miocene alluvium (Quaternary to late Tertiary)
Moderately consolidated, clast-supported, very coarse-grained, poorly sorted pebble to boulder alluvial deposits with clasts up to 3 m. Clasts resemble bedrock at Black Mountain, are coarser near Black Mountain, and are inferred to have been derived from it. These deposits may have been deposited, in part, by debris flows and/or rock avalanches. Rocks of this unit could be derived from underlying Tertiary boulder fanglomerate of map unit Tcg, reworked underlying fanglomerate, or Quaternary deposits carried in strams from bedrock source areas.

QTs — Surficial deposits, undivided (Quaternary to late Tertiary)
Undivided early Quaternary and late Tertiary consolidated to unconsolidated sediments. QTs includes highly eroded carbonate-bearing deposits that underlie much of the map area and support the Falcon Divide, which runs NE-SW across the southeastern portion of the map area. QTs appears white and gray in aerial photos and is evidenced by petrocalcic chip lag on surfaces stripped of overlying soil horizons. This unit often encompasses eroded QTcr remnants, and is occasionally traceable above and between outcrops of QTcr in gullies and on cut bank exposures. Creosote and ocotillo frequent areas of high carbonate exposure, and yucca, cholla, mesquite, grass, prickly pear, and other cacti are common to these deposits.

QTcr — Mixed soil, regolith, and conglomerate and sandy conglomerate (Quaternary to late Tertiary)
QTcr is a mixed unit that includes soil and regolith developed on conglomerate and sandy conglomerate of map unit QTcs, and includes poorly exposed outcrops of QTcs. QTcr also locally includes soil and regolith development on San Manuel conglomerate. QTcr forms low hills throughout the northeastern portion of the map area with actively forming soils.

QTcs — Conglomerate and sandy conglomerate (Quaternary to late Tertiary)
Light gray, poorly sorted to massive conglomerate and sandy conglomerate. Clasts are commonly dominated by locally derived granite but include a varying, minor proportion of Cloudburst Formation volcanic clasts and Precambrian sedimentary clasts. In one area near Fortified Peak clasts do not resemble local granite which suggests that the conglomerate was juxtaposed with the bedrock by faulting. The matrix is composed of medium to coarse sand and granules and cemented by carbonate. Typically a crudely bedded, moderately well indurated pebble to small boulder conglomerate. Clasts sizes decrease toward the east and northeast where the unit becomes weakly consolidated sands, gravels, and granule to cobble conglomerate. Very thin sandy layers within the conglomerate generally show a gentle dip to the south. This unit may be equivalent in part to the granite-clast conglomerate (map unit Tcg) exposed to west, and to similar conglomerates in the North of Oracle 7½' quadrangle to the east, but a definitive correlation can not be made.

Tertiary map units

Tcg — Granite-clast conglomerate (middle Tertiary)
Light gray, poorly sorted conglomerate dominated by granite clasts up to 3 meters in diameter. Locally this unit contains abundant soft calcium carbonate veinlets. Near the fault contact with bedrock this unit is stained by hematite and clasts are crushed.

Ts — Sandstone (middle Tertiary)
Generally tan to pinkish buff, poorly to moderately indurated, poorly sorted medium to very fine-grained sandstone. Typically very poorly exposed, recognized by soil and small outcrops along washes. Very thin bedded where bedding is visible. Commonly contains scattered pebbles or cobbles and occasional interbedded conglomerate lenses. Clasts are Tertiary(?) basalt, granitoids, and sparse quartzite.

Txg_2 — Younger rock avalanche breccia derived from granite (middle Tertiary)
Rock avalanche breccia derived from medium grained, equigranular, biotite granite or granodiorite and less abundant other rock types including mylonitic granite and quartz veins. Exposures that reveal the breccia character of this rock unit are rare, and in the vast majority of exposures the rock unit appears as a rubble of clasts with a soil and sand matrix. Quartz veins, however, are typically highly shattered and well cemented, and so reveal the breccia nature of the map unit. Mapped as poorly exposed deposits interbedded with conglomerates along the west edge of the map area from Suffering Wash south almost to Coronado Wash.

Txp — Younger rock avalanche breccia derived from schist (middle Tertiary)
Rock avalanche breccia composed of angular boulders of schist and gneiss. The source rock type for this unit may have been Pinal Schist.

Tsm — San Manuel Formation (middle Tertiary)
Light gray to brownish gray, gently dipping, pebble to cobble conglomerate. The matrix is sandy and cemented with silica. Thin- to medium-bedded, poorly to moderately well-sorted, and moderately indurated. Clast composition is dominated by angular to subrounded volcanic and granitic clasts, present in varying proportions, with sparse subrounded clasts of quartzite and limestone. Deposited on an angular buttress unconformity in steeply dipping Cloudburst Formation volcanic and sedimentary rocks.

Cloudburst Formation and related volcanic and sedimentary rocks

Tri — Hypabyssal(?) rhyolite (middle Tertiary)
Light colored, fine-grained, aphyric rhyolite that forms a few small pods within the Cloudburst Formation lava flows. These rocks are poorly exposed and very fractured, and may represent small hypabyssal dikes or plugs. The possibility that this is a rhyolite flow, however, cannot be ruled out.

Tt — Welded tuff (middle Tertiary)
Pinkish tan welded tuff with abundant subangular lithic and pumice fragments ranging in size from 2-3 mm up to 3 cm. Contains 5-10% phenocrysts of plagioclase, sanidine, quartz, and biotite. The tuff unit forms a single bed, about 8 m thick at maximum thickness, within Cloudburst Formation conglomerate. The unit is strongly jointed and breaks into small plates, especially at the inferred stratigraphic top of the bed. The relative percentage of lithic fragments increases towards the inferred stratigraphic bottom. Sanidine from a sample of this tuff from the North of Oracle 7½' quadrangle to the east (Orr et al., 2004,) yielded a sanidine 40Ar/39Ar date of 26.3 ± 0.1 Ma (Peters et al., 2003).

Tc — Conglomerate, undivided (middle Tertiary)
Medium brown to reddish brown conglomerate and, locally, sandy conglomerate. Most of the conglomerate is massive to poorly bedded and poorly sorted. The clast composition in the southern areas of conglomerate exposure is dominated by angular to subrounded pebbles, cobbles, and boulders of granite and quartzite, with common limestone clasts, up to about 2 m in diameter, and a variable proportion of pebbles and cobbles of mafic to intermediate volcanics that were probably derived from Cloudburst Formation volcanic rocks. In the northern portion of the conglomerate exposure, the clasts consist dominantly of subangular to subrounded pebbles and cobbles of mafic to intermediate volcanics likely derived from the Cloudburst Formation volcanics, with common granite pebbles and cobbles and minor quartzite clasts. In some areas, almost all clasts were derived from mafic to intermediate, variably vesicular, aphyric volcanics. This unit locally contains thin, mafic lava flows, thin beds of brown colored, pumiceous coarse sand, and small deposits of granite-clast and quartzite-clast avalanche breccia. Breccias may be prevalent in the southern exposures of the conglomerate, but were not mapped separately due to lack of exposure and similarity in clast composition to the conglomerate.

Txg_1 — Older rock-avalanche breccia derived from granite (middle Tertiary)
Reddish colored avalanche breccia derived from K-feldspar porphyritic granitoid. Breccia fragments typically < 50 cm diameter. Mapped as small outcrops within Cloudburst Formation rocks in the northeast portion of the map area.

Tm_1 — Mafic to intermediate volcanic rocks, fine-grained (middle Tertiary)
Medium brown to dark gray, fine-grained, mafic to intermediate lava flows, flow breccias, and massive volcanic-lithic, clast-supported breccias (2-20 cm fragments) that are probably autoclastic breccias. Many of the flow breccias and the tops of some flows are oxidized to a brick red color. These volcanic rocks are petrographically similar to lavas found to the west in the Chief Butte 7½' quadrangle that chemically range from basalts to trachyandesites. The lavas are typically vesicular to amygdaloidal with round to flattened vesicles and cavities up to 15 cm in diameter. The amygdules, composed of calcite or silica, often weather out, and in many areas the ground is littered with white, egg-shaped silica nodules from less than 1 cm up to several cm in diameter. Locally includes bedded pyroclastic rocks or reworked basaltic pyroclastic rocks, including thin beds of brown colored, pumiceous coarse sand, conglomerate, and granite-clast avalanche breccia. Sparse massive conglomerate beds derived from mafic to intermediate lava flows, where not mapped separately, are also included in this unit.

Tm_2 — Mafic to intermediate volcanic rocks, medium-grained (middle Tertiary)
Coarsely crystalline, seriate textured variety of Tm_1 lava as described above. Contains phenocrysts of green-colored clinopyroxene (~15% to 20%, probably augite) ranging in size from about 0.5 mm to 3 mm, and reddish brown olivine (~10% to ~15%), mostly altered to iddingsite, that range in size from about 0.25 mm to 2 mm. The matrix is composed of plagioclase laths that range in length from about 0.5 mm to 2 mm.

Tertiary to Proterozoic igneous rocks

TYs — Shear zone rocks (middle Tertiary to Middle Proterozoic)
Strongly foliated, low angle shear zone in the Suffering Gulch area (sections 19 and 20, T. 8 S., R. 14 E.) representing top-to-the-south movement and characterized by greenish colored, strongly foliated amphibolite schist; mylonitic K-feldspar porphyritic granitoid (Yg); and crushed quartz cemented with silica. The amphibolite schist, which has been chloritized and epidotized, may have been a mafic dike, but probably represents a sheared enclave of Pinal Schist. Biotite from a sample of Proterozoic granite from Black Mountain yielded an 40Ar/39Ar isochron date of 72.56 ± 0.37 Ma (Spell et al., 2003), which suggests that the mylonitic deformation must have been older that this date because during more recent times the rocks have been too cool to undergo such deformation.

TYr — Porphyritic rhyolite dikes (middle Tertiary to Middle Proterozoic)
Light colored, crystal-poor, porphyritic rhyolite containing about 1% subhedral quartz phenocrysts (~1-3 mm) and less than 1% muscovite phenocrysts (~1 mm) in an aphanitic groundmass. Occurs as discontinuous dikes ranging in width from a few cm to less than 5 m. The rock is relatively resistant, usually forming small ridges, is jointed parallel to the orientation of the dike wall, and breaks into small angular fragments. This map unit is probably correlative with the "quartz latite or rhyolite porphyry" dikes of Krieger (1974a) mapped to the north on the Black Mountain 7½' quadrangle.

TYi — Fine-grained intermediate dikes (middle Tertiary to Middle Proterozoic)
Tan to pinkish-tan, fine-grained, equigranular intermediate dikes, with anhedral to subhedral phenocrysts of plagioclase up to about 2 mm, anhedral biotite crystals (5-15 %) about 1 mm across, and anhedral to subhedral hornblende phenocrysts (2-5 %) up to about 8 mm. Near the dike margins the rock becomes plagioclase microporphyritic with a microcrystalline matrix and typically has a distinctive reddish color banding probably caused by weathering. This rock is exposed as a single, nearly continuous dike to the east of Fortified Peak (sections 20 and 29, T. 8 S., R. 14 E.), and is relatively resistant compared to the host granite (Yg) forming a low but distinct ridge mantled with subangular cobbles.

TYp — Porphyritic intermediate dikes (middle Tertiary to Middle Proterozoic)
Light brown to pinkish brown, seriate-textured, porphyritic intermediate dikes, with anhedral to subhedral phenocrysts of plagioclase from about 1 mm to 1 cm; rare euhedral plagioclase phenocrysts up to about 4 cm; tabular to globular phenocrysts of hornblende up to 1 cm; and biotite phenocrysts up to 3 mm. The rock has a microcrystalline matrix and locally contains miarolitic cavities up to 1 cm across. Rocks of this map unit are relatively resistant compared to the host granite (Yg) and form low ridges and distinct breaks in slope.

TYd — Fine-grained microdiorite dikes (middle Tertiary to Middle Proterozoic)
Fine-grained, equigranular microdiorite dikes. Weathered surfaces appear light to medium brown while fresh surfaces are gray. Where exposed to the east of Tipperary Wash (sections 12 and 13, T. 8 S., R. 13 E.), this rock is extremely hard and very resistant, forming a pronounced, discontinuous ridge mantled by talus. Along strike from this dike, to the east of Tipperary Well (northeast corner section 23, T. 8 S., R. 13 E.), a small, medium-grained dike of similar composition invades, and contains xenoliths of, a felsic, quartz-feldspar dike. Southeast of Fortified Peak (southwest corner of section 29, T. 8 S., R. 14 E.) another dike of similar composition intrudes Yg granitoid and contains numerous, corroded xenoliths.

TYgp — Pegmatitic granite dikes (middle Tertiary to Middle Proterozoic)
In the Tipperary Wash/Miller Wash area, this granite consists of commonly muscovitic, texturally variable granitic dikes and pegmatite dikes that locally contain garnet. Dikes of this unit are too numerous in some places to map separately and have therefore been mapped as areas of dike swarms. The dike swarms consist of parallel pegmatite dikes with screens of granite, Pinal Schist, and possibly granite with flow fabrics that make the rock resemble Pinal Schist. Mylonitic fabrics in host Proterozoic granite of map unit Yg are cut by these dikes. Muscovite from a sample of this unit yielded an 40Ar/39Ar plateau date of 40.61 ± 0.28 Ma (Spell, et al., 2003). These dikes are probably related to the Eocene leucogranites in the nearby Suizo, Tortolita, and Santa Catalina Mountains (Keith et al., 1980; Force, 1997, p. 43; Spencer et al., 2003; Ferguson et al., 2003). It is possible, however, that the muscovite date is a cooling date unrelated to crystallization age, and this unit is related to 1.4 Ga leucogranite muscovite granite to the northeast (Krieger, 1974b; Orr, et al., 2004).

Pegmatite dikes related to muscovite granite of map unit Ygm (Middle Proterozoic)
East of Suffering Gulch, rocks of this unit are shown on the map with a pegmatite-dike symbol. These dikes consist of light-colored, very coarse-grained pegmatite dikes with anhedral phenocrysts of quartz and anhedral masses to euhedral crystals of feldspar up to 10 cm. Dikes contain anhedral books of muscovite up to 4 cm thick and 10 cm across, masses of black tourmaline, rough tourmaline crystals up to 3 cm across and 20 cm long, and rare fractured crystals of beryl ranging from ~1 cm to 3 cm in width. The pegmatite dikes are thought to be a late stage differentiate of the quartz-feldspar-muscovite granite (Ygm) present in the same area. These pegmatite dikes often grade laterally and along strike into Ygm dikes, as well as intrude Ygm granite, which has been dated at 1433 Ma.

TYbg — Biotite granite (middle Tertiary to Middle Proterozoic)
Fine-grained granite with up to 10% biotite, with dikes and small bodies of felsite containing biotite phenocrysts up to 10 mm diameter and K-feldspar(?) phenocrysts up to 10 mm. This rock unit is probably either a late stage, somewhat alkaline magmatic differentiate of Oracle Granite and related granitoids, or is a Laramide or mid-Tertiary, slightly alkalic intrusion.

Middle Proterozoic map units

Ygm — Muscovite granite (Middle Proterozoic)
Light-colored, fine- to medium-grained, equigranular granite that intrudes K-feldspar porphyritic granitoid (Yg) as dikes and large, irregular bodies. Characterized by anhedral phenocrysts of quartz and feldspar less than 5 mm in width; thin, anhedral to subhedral books of fresh muscovite (~5-15%) from less than 1 mm to about 1 cm across; and thin, anhedral books of fresh biotite (<1-10%) from less than 1 mm to about 5 mm across. Resistant compared to the granitoid (Yg) it intrudes, often forming pronounced ridges mantled with minor blocky talus. Zircon from a sample of this granite yielded a U-Pb date of 1433.5 ± 2.0 Ma (Spencer et al., 2003). Muscovite from a sample of this unit yielded an 40Ar/39Ar total gas date of 1033 ± 5 Ma (Spell et al., 2003).

Yg — K-feldspar porphyritic granitoid (Middle Proterozoic)
Light gray to medium gray, coarse-grained, K-feldspar porphyritic monzogranite to granodiorite. Phenocrysts visible in hand sample include light-colored, anhedral to tabular crystals of K-feldspar up to about 3 cm in length; white to greenish, anhedral, sericitized plagioclase up to about 1 cm; rounded quartz crystals less than 1 cm; and 20-40% fresh, anhedral crystals of dark biotite forming thin books up to 3-4 mm in width and irregular clots up to 2 cm across. Small, biotite-rich selvages are widespread throughout the unit. In the northeast corner of the map area small, fine-grained, mafic-rich zones, possibly epidote and magnetite bearing, are locally adjacent to, or form screens between, pegmatite dikes. A few of the larger mafic pods have been plotted on the map. The granitoid typically weathers into outcrops of large, rounded boulders. There is also a megascopic joint pattern oriented north-northeast that is visible in aerial photographs but difficult to discern at outcrop scale. This joint pattern appears to have influenced the development of stream drainages in the granitoid. In the northwest part of the map area the granitoid intrudes Pinal Schist and schistose xenoliths are common. The granitoid is contiguous with the Ruin Granite unit of Krieger (1974b) on the adjacent Black Mountain 7½' quadrangle.

Early Proterozoic map units

Xp — Pinal Schist (Early Proterozoic)
Light silvery gray to brownish gray, fine- to medium-grained, sericitic to chloritic schist. The schist often grades into thin-banded biotite paragneiss with migmatitic bands from 2 to about 5 mm wide generally making up 5% to 10% of the rock. Sparse porphyroblasts of garnet up to 3 mm are present, as well as ubiquitous opaques, probably magnetite, less than 0.25 mm. A well developed schistosity is often strongly crenulated. Pinal Schist is found in the northwest part of the map area (sections 5 and 23, T. 8 S., R. 13 E.) where it is intruded by granitoid of map unit Yg and quartz-feldspar-muscovite pegmatite dikes of map unit TYgp. The foliation in the schist (approximately NW-striking) is roughly parallel to the orientation of pegmatite dikes in the area as well as to the orientation of the normal fault that bounds the southwest edge of the Black Mountains here.

GEOLOGIC MAP SYMBOLS

Bedding
- Horizontal planar bedding
- Inclined planar bedding
- Vertical planar bedding
- Contorted or variable bedding
- Apparent dip of bedding

Joints
- Inclined joint

Foliation and Cleavage
- Inclined tectonite foliation
- Inclined schistosity
- Mylonitic foliation, with stretching lineation
- Mylonitic foliation, with stretching lineation showing normal sense of shear
- Spaced cleavage

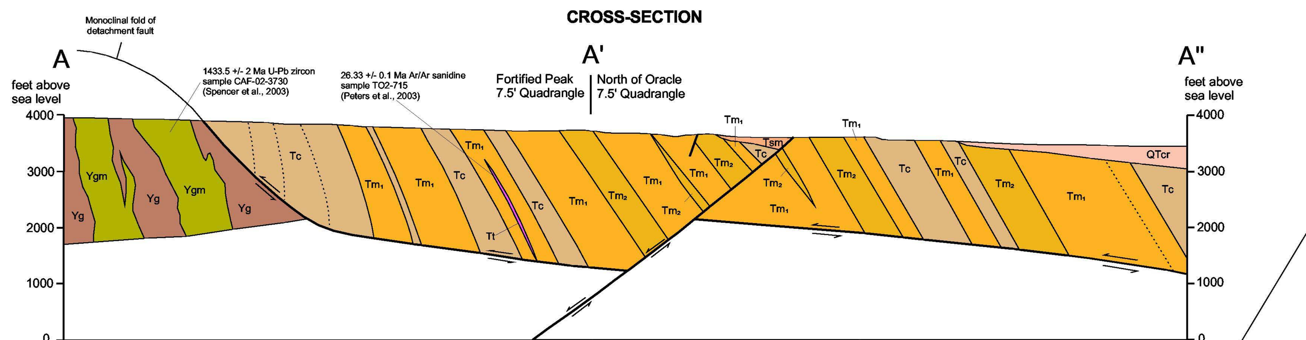
Other Symbols
- Sample location / geochronology point

Dikes and Marker Beds
- Pegmatite dikes
- Felsic dikes
- Rhyolite dikes
- Intermediate dikes
- Mafic dikes
- Veins
- Marker beds

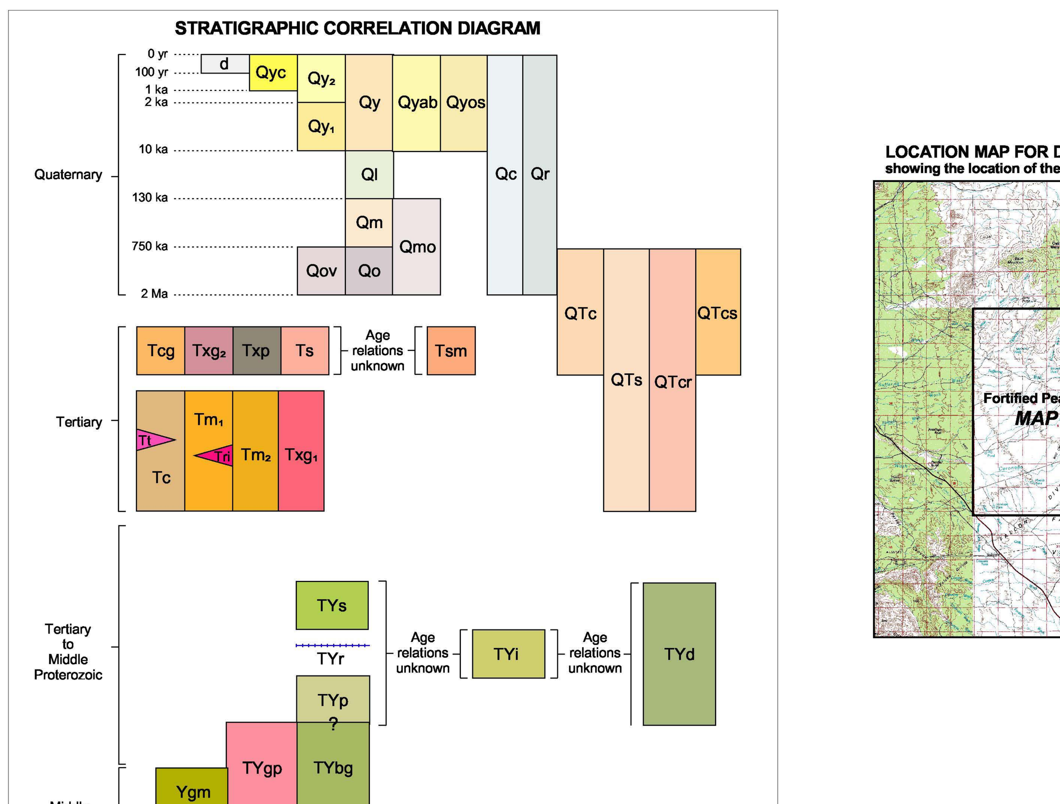
Contacts
- Contact, showing orientation of contact surface (dashed where approximately located; queried where location guessed; tics represent cut banks along washes (only locally mapped))

Faults
- Normal fault, showing dip and dip direction of fault surface (dashed where approximately located; queried where location guessed; dotted where concealed; ball and bar symbol indicates hanging wall)
- Detachment fault (dashed where approximate; dotted where concealed)
- Low-angle fault/shear zone (dashed where approximate; dotted where concealed)
- Mylonitic shear zone

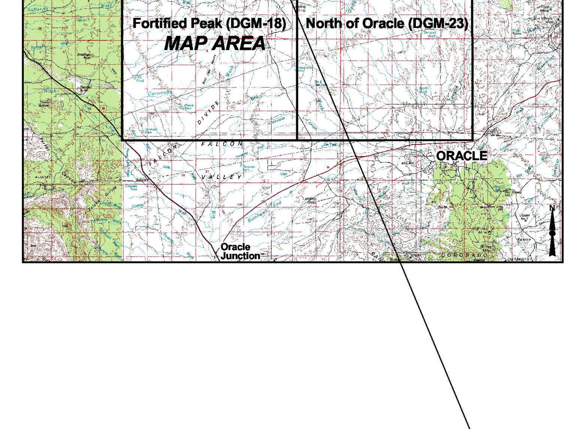
CROSS-SECTION



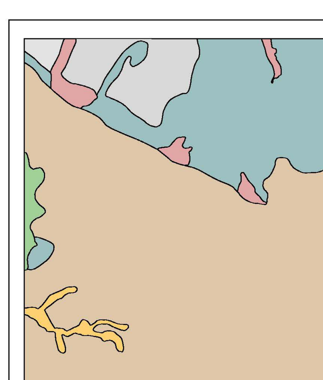
STRATIGRAPHIC CORRELATION DIAGRAM



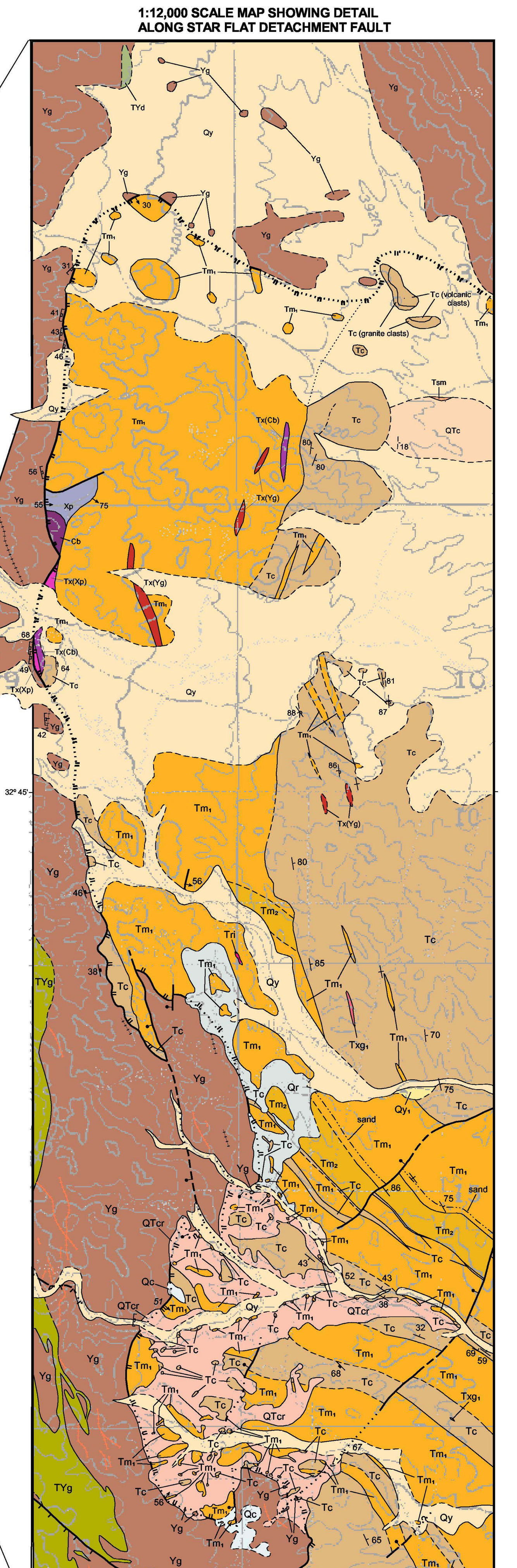
LOCATION MAP FOR DGM-18
showing the location of the Fortified Peak and North of Oracle 7½' quadrangles



SIMPLIFIED MAPPING RESPONSIBILITY DIAGRAM



- Spencer
- Richard
- DeLong
- Orr
- Orr and Spencer
- Aerial photo interpretation and extrapolation from nearby areas

Additional surficial mapping by DeLong throughout map area

1:12,000 SCALE MAP SHOWING DETAIL ALONG STAR FLAT DETACHMENT FAULT