DIGITAL GEOLOGIC MAP DGM-69

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Geologic Map of the Peppersauce Wash 7½′ Quadrangle and Part of the Kielberg Canyon 7 ½′ Quadrangle, Pinal and Pima Counties, Arizona, version 1.0

August, 2009

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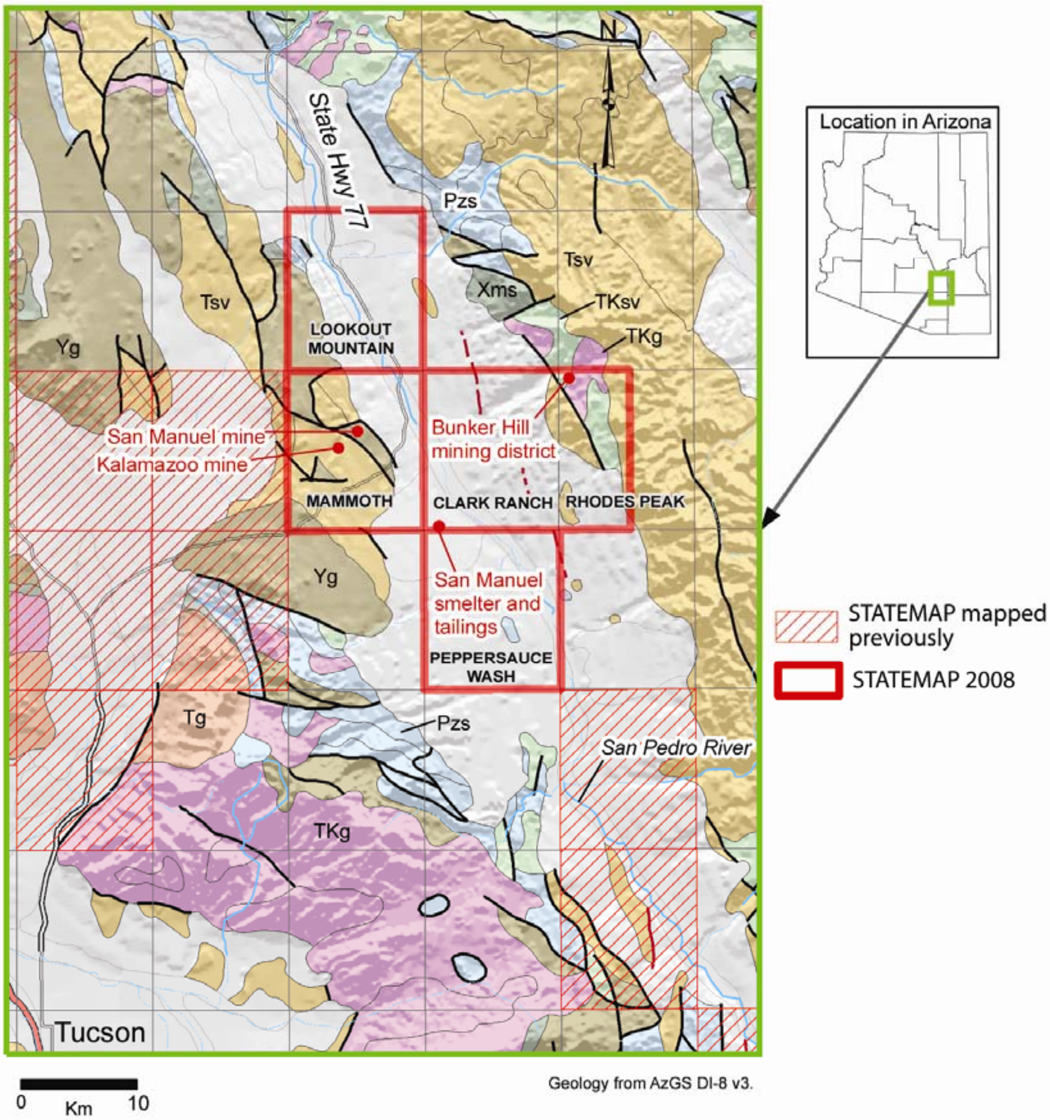
INTRODUCTION

The Peppersauce Wash 7 ½' Quadrangle and the southwestern part of the Kielberg Canyon 7 ½' Quadrangle include part of the San Pedro River lowlands, flanking valley fill on both sides of the river, and limited bedrock outcrops (Fig. 1). Production of this new geologic map continues the Arizona Geological Survey mapping program of the San Pedro River valley. This 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 Geological Survey and the U.S. Geological Survey under STATEMAP Program Contract award number 07HQAG0110. Mapping was developed from previous mapping, new field investigations, and interpretation of color orthophotography taken in 2007. Mapping was compiled digitally using ESRI ArcGIS software.

The surficial deposits of the Peppersauce Wash 7½' Quadrangle were mapped previously on a reconnaissance basis by Pearthree et al (1988), and the northern 1/3 of the quadrangle was mapped by Steven J. Skotnicki as part of an unpublished mapping effort. During the past several decades, William R. Dickinson has focused on the middle to late Cenozoic strata and structure of the San Pedro Trough (Dickinson, 1987, 1991, 1998, 2003). New mapping done for this study was directed primarily at Quaternary deposits and surfaces, but includes older strata and rocks in some areas. Bedrock was mapped previously by Creasey (1967).



Tsv - Oligo-Miocene sedimentary and volcanic rocks
Tg - Oligo-Miocene granitic rocks
TKg - Early Tertiary and late Cretaceous (Laramide) granitic rocks
TKsv - Early Tertiary and Cretaceous sedimentary and volcanic rocks
Pzs - Paleozoic sedimentary rocks
Yg - Mesoproterozoic granitic rocks
Xms - Paleoprotoerozoic metasedimentary rocks

Figure 1. Geologic map of the lower San Pedro River valley area, southeastern Arizona, showing STATEMAP 2008 map areas.

MAP UNIT DESCRIPTIONS

SURFICIAL MAP UNITS

d **Disturbed ground –** Disturbed ground due to mining activity, agriculture, extensive excavation, or construction of earth dams.

Qtc **Colluvium and talus (late Quaternary) –** Very poorly sorted, angular to subangular, locally derived, weakly bedded, moderately to steeply dipping slope deposits associated with bedrock hills.

San Pedro River Alluvium

Qycr **Active River Channel Deposits -** Deposits are dominantly unconsolidated, very poorly sorted sandy to cobbly beds exhibiting bar and swale microtopography but can range from fine silty beds to coarse gravelly bars in meandering reaches based on position within the channel. Clasts are typically well-rounded but may be angular to sub angular. Qycr deposits are typically unvegetated to lightly vegetated and exhibit no soil development. Qycr deposits are entrenched from 30 cm to 10 meters or more below adjacent early historical floodplain deposits depending on location, geomorphic relationship, and local channel conditions. Although much of the San Pedro was a perennial stream historically, some sections are dry or marshy at the surface during much of the year. These deposits are the first to become submerged during moderate to extreme flow events and can be subject to deep, high velocity flow and lateral bank erosion.

Qy4r **Flood channel and low terrace deposits -** Deposits are found adjacent to active channels that form lightly vegetated in-channel bars, small planar fluvial terraces within 30 cm of river elevation, and recent erosional meanders outside the presently active channel. Terrace deposits are inset into older river alluvium and usually narrow, rarely more than 100 meters across. Qy4r deposits are composed of poorly sorted unconsolidated sediments ranging from fine silts to gravel bars depending on location in the channel at the time of deposition. Pebbles and cobbles are well-rounded to sub-rounded. These surfaces are commonly inundated under moderate to extreme flow events and can be subject to deep, high velocity flow and lateral bank erosion. These deposits do not exhibit soil development but may exhibit a light vegetation cover of small trees and bushes and grasses due to their relatively frequent inundation.

Qy3r **Historical river terrace deposits -** Terrace deposits that occupy elevations from 1 to 2 meters above Qy4r deposits and are inset below the pre-incision historical floodplain. These surfaces are generally planar but exhibit bar and swale microtopography. Although no soil development is present, dense grasses and small mesquite trees abound. Sediments composing these deposits are poorly sorted silt, sand, pebbles and cobbles. Pebbles and cobbles are well-rounded to sub-angular. Trough crossbedding, ripple marks, and stacked channel deposits viewable in cross-section indicate deposition in a low to moderate energy braided stream environment. These deposits are prone to flooding during extreme flow events, and undercutting and rapid erosion of Qy3r surfaces is possible during lower flow events.

Qy2r **Latest Holocene to historical river deposits** - Deposits associated with the floodplain that existed prior to the early historical entrenchment of the San Pedro River (Hereford, 1993; Huckleberry, 1996; Wood, 1997). Qy2r deposits are associated with broadly planar surfaces that locally retain the shape of historical river meanders. Qy2r surfaces are up to 7 meters above modern Qycr deposits and are the most extensive river terraces in the valley. Qy2r sediments were deposited when the San Pedro was a widespread, shallowly-flowing river system and are dominated by fine grained floodplain deposits. Dense mesquite bosque and tall grass is typically present on these surfaces except where historic plowing or grazing has taken place. These surfaces appear predominantly fine grained at the surface due in part to the input of organic matter and windblown dust deposition but are composed of interfingering coarse sandy to pebbly braided channel and fine sand to silty river floodplain deposits. Where Qy2r deposits are moderately to deeply incised they not subject to inundation by river floods, but they may be flood-prone in areas with less channel incision. Qy2r deposits are subject to catastrophic bank failure due to undercutting and lateral erosion during flow events. Distal piedmont fan deposits (Qy2 and Qy2f) onlap onto Qy2r deposits although an interfingering relationship likely exits in the subsurface.

Qy1r **Late to Early Holocene San Pedro terrace deposits** - Deposits associated with slightly higher terraces that represent either higher elements of the early historical floodplain or remnants of older Holocene aggradation periods. These fine-grained terrace deposits commonly have been disturbed by plowing or cattle grazing. When undisturbed, Qy1r deposits are densely vegetated by mature mesquite trees (mesquite bosque) and tall grasses. Soil development is moderate and surface color ranges from 10 to 7.5 YR 4/4. Due to the dense vegetation input of organic matter at the surface is high and often results in a thin (< 10 cm) organic soil horizon. A light dusting (incipient stage I) calcium carbonate accumulation is evident on the undersides of some buried clasts. Qy1r surfaces are up to 7 meters above the active channel in highly incised locales and typically are less than 1.5 m higher than adjacent Qy2r surfaces.

Qi3r **Late Pleistocene river terrace deposits** - Terrace deposits are up to 10 to 25 m higher than and up to 500 m outside the margins of the modern San Pedro channel. These deposits consist of well rounded pebbles to cobbles exhibiting stage I+ calcium carbonate accumulation with cross-bedded coarse sandy interbeds. Clast composition is varied and includes rock types not found in the mountains from which modern piedmont material is derived from. Qi3r terrace surfaces are planar, often surrounded by distal piedmont alluvium, and are generally lightly vegetated except for small weeds and grasses. Commonly, Qi3r deposits are inset into adjacent piedmont alluvial deposits but can also be inset into older river gravel terraces. Soil development is weak, possibly due to the porous nature of these deposits.

Qi2r **Middle Pleistocene river terrace deposits** - Terrace deposits are similar to Qi3r deposits but occupy somewhat higher positions in the landscape. The margins of terrace surfaces are slightly to moderately rounded. Clast composition is diverse. Well-rounded pebbles to cobbles with stage I-II calcium carbonate accumulation armor Qi2r surfaces. Vegetation is sparse, consisting of small shrubs and grasses. Soil development is generally weak on

Qi2r surfaces, but soil development is more evident in finer grained sections. Qi2r surfaces are typically found as high-standing isolated mounds surrounded by distal fan alluvium or as small terraces inset into older fan or basin fill alluvium.

Qi1r **Early to middle Pleistocene river gravel terraces** - Deposits are associated with high-standing, well-rounded river gravel terraces. Where Qi1r deposits are extensive, remnant planar caps are preserved near the center of the surface. Qi1r deposits are composed of very well rounded to well rounded pebbles and cobbles from diverse lithologies. Cross-bedded sands with pebbly stringers are interbedded throughout. Near-surface cobbly beds exhibit stage II+ calcium carbonate accumulation. Moderately to strongly calcium carbonate coated clasts or cemented aggregates of clasts mantle the flanks of Qi1r deposits, but clay accumulation is variable, probably due to poor surface preservation. Sparse small shrubs, weeds, and cacti are present on these surfaces.

Piedmont Deposits

Qyc **Active tributary channel alluvium** - Unconsolidated, very poorly sorted sandy to cobbly piedmont channel sediments. Channels may exhibit bar and swale microtopography with bars composed of coarser sediments. Qyc deposits are typically unvegetated and exhibit no soil development although small shrubs and grasses can be found on slightly elevated bars. Qyc deposits commonly become submerged during moderate to extreme flow conditions and can be subject to deep, high velocity flow and lateral bank erosion. Channels are generally incised 1 to 2 m below adjacent Holocene alluvium and may be incised into adjacent Pleistocene alluvium by 10 m or more.

Qy3 **Latest Holocene alluvium** - Recently active piedmont alluvium located primarily along active tributary drainages including floodplain, low-lying terrace, and overflow channels. Qy3 deposits are composed of unconsolidated to very weakly consolidated silty to cobbly deposits and exhibit greater vegetation than Qyc deposits. These deposits generally exhibit bar and swale meso-scale topography and are susceptible to inundation during moderate to extreme flow conditions when channel flow exceeds capacity. Soil development is generally absent or incipient on Qy3 deposits which exhibit pale buff to light brown (10 YR) surface coloration.

Qy2 **Late Holocene alluvium** - Piedmont terrace deposits located primarily along the flanks of incised drainages and ephemeral washes, on broad low-relief distal fans onlapping onto Holocene river alluvium, and along small tributary drainages. These deposits consist of predominantly fine grained unconsolidated to weakly consolidated sediments although isolated sub-rounded to sub-angular cobbles and boulders may be present at the surface in small quantities. Where inset into older alluvium, Qy2 deposits are planar with remnant bar and swale meso-scale topography. Distal fan Qy2 deposits are broad and sandy with numerous small braided channel systems. Soil development on Qy2 deposits is weak, characterized by incipient stage I calcium carbonate accumulation in the form of small filaments and medium brown (10 YR) surface coloration. Vegetation on Qy2 surfaces ranges from numerous small mesquite trees and grasses in distal fan environments to medium creosote, acacia, and cholla in tributaries and inset terraces. These surfaces are subject to inundation during moderate to extreme flow conditions when channel flow exceeds capacity or due to channel migration on low-relief portions of broad distal fan deposits. Qy2 terraces are typically elevated from 0.5 to 1.5 m above active channels.

Qy1 **Early to late Holocene alluvium** - Deposits consist of broad, low-relief, undulating fan deposits that sit higher in the landscape than younger Holocene alluvium. Portions of these deposits are mantled by coarse to very coarse angular quartz sand and exhibit diverse vegetation patterns dominated by cholla, prickly pear, small (1-1.5 m tall) mesquite, and numerous small shrubs and grasses. Overall relief between broad fan crests and incised drainages on gently rolling Qy1 deposits typically does not exceed 1.5 meters. Numerous shallow braided channels drain widespread portions of Qy1 surfaces. Qy1 deposits exhibit visible calcium carbonate accumulation (stage I to II) and are characterized by medium brown (10-7.5 YR) coloration in near-surface horizons. Deposition of Qy1 sediments in a braided channel aggrading alluvial fan environment has, in places, resulted in shallow burial of adjacent piedmont deposits. This relationship is visible along incised channels where thin Qy1 deposits overly redder, grusy, clay-rich Qi2 or Qi3 deposits.

Qi3 **Late Pleistocene alluvium** - Qi3 deposits widespread planar reddish fan terraces mantled by angular to sub-angular pebbles to boulders. These deposits exhibit moderate calcium carbonate accumulation (stage I to II) and soil development with reddish shallow subsurface coloration (7.5 YR 4/4). This color varies with position in the piedmont due to differences in parent material (mixed granitic, metamorphic and volcanic clasts west of San Pedro and volcanic clasts to the east). Qi3 deposits have saguaro, palo verde, mesquite, cholla, prickly pear, creosote, acacia, and numerous small grasses and shrubs. Qi3 deposits stand up to 3 to 4 meters higher in the landscape than adjacent Qy1 and Qyc deposits depending on local incision and position within the piedmont.

Qi2 **Middle to late Pleistocene alluvium** - Qi2 deposits form broad planar fan and terrace surfaces that cap Quiburis basin fill deposits. These deposits are inset below older or lining the margins of piedmont drainages. These deposits generally exhibit reddish (7.5-5 YR 5/4) soils and moderate calcium carbonate accumulation (stage I to II+). Varnish and pavement development is moderate to poorly exhibited. Qi2 deposits are overall planar but can exhibit mild to moderate rounding near incised channels or inset terraces. Vegetation on Qi2 surfaces consists of saguaro, palo verde, medium mesquite, prickly pear, cholla, barrel cactus, and numerous small shrubs and short grasses. Where incised, these deposits often exhibit a cap up to 1 meter thick of moderately calcium carbonate cemented clasts. This cap preserves underlying, less-indurated portions of the Qi2 surface as well as any deposits it may overly. Qi2 terraces deposited onto basin fill deposits may stand as much as 20 meters above active piedmont channels.

Qi1 **Early to middle Pleistocene alluvium** - Qi1 deposits are characterized by high-standing, moderately to well-rounded alluvial deposits exhibiting strong (stage II to III) calcium carbonate accumulation and, where preserved, dark reddish (5-2.5 YR 4/6) soils. Like Qi2 deposits, Qi1 deposits may cap underlying Quiburis basin fill deposits. Where widespread (greater than 30 meters across), Qi1 deposits retain a remnant, indurated planar cap with moderately to well rounded edges. Narrow (less than 30 meters across) Qi1 terraces and caps are generally well-rounded and do not exhibit a planar remnant. Qi1 terraces are commonly mantled by coarse pebbles to boulders, sub-angular to sub-rounded and exhibit vegetation consisting of medium to large mesquite, acacia, saguaro, palo verde, prickly pear, cholla, barrel cactus, and grasses. In places cholla dominate and are densely packed. Varnish and clay-coatings are weak to moderate and common on overturned clasts and desert pavement is poorly to moderately exhibited.

Figure 2. Weakly to moderated indurated Qi1 fan deposits with reddened, relatively clay-rich soil unconformably overlies gray to pink, finer-grained Tqs (Quiburis Formation) deposits.

Qo **Early Pleistocene fan gravel** - Deposits associated with the highest relict alluvial surfaces. A remnant planar cap may be present on extensive surfaces such as ancestral planar alluvial fans. Where preserved, soils on Qo surfaces exhibit clay rich argillic and well developed calcic horizons. Dark red soils (2.5 YR 4/6) are sparsely covered by mild to moderately varnished pebbles to small cobbles. Near surface soil is loamy and overlies much coarser clasts visible on the eroded flanks of Qo surfaces. Vegetation consists of tall saguaro, palo verde, prickly pear, mesquite, and isolated creosote. Remnant argillic horizons exhibit clay faces, blocky ped structures, and are deep red in color. Exposures of the calcium carbonate horizon exhibit stage III to IV accumulation. Qo deposits average 5 meters to as much as 15 meters thick. Aggregate chunks of eroded portions of the carbonate horizon commonly litter the flanks of Qo and underlying deposits. Qo surfaces generally occupy the highest position in the landscape, capping Quiburis basin fill deposits (e.g., highest ridge on cover photo). Thin relict ridge-capping reaches of Qo deposits are commonly encountered where the underlying basin fill deposits are highly eroded and incised. Underlying basin fill deposits stand much higher in the landscape relative to comparable, uncapped deposits.

QTa **Late Pliocene to early Pleistocene fan gravel** - Coarse gravelly deposits that erosionally overlie Quiburis basin-fill sediments and form the upper parts of high, very rounded ridges. QTa deposits are composed of very poorly sorted angular to sub angular sand, pebbles, cobbles, and boulders arranged in alternating fine to coarse beds common in alluvial fan deposits. High standing rounded ridges are composed of carbonate-cemented fanglomerate cap which armors the underlying, less indurated basin-fill sediment. The flanks of QTa ridges are also armored against erosion due to the mantle of coarse clast cover derived from weathered sections of the cap. Exposures of QTa deposits are generally poor, but they may locally be at least 30-40 meters thick and are commonly the highest standing deposits in the proximal piedmont. Locally these deposits are capped by very old, very high relict Qo alluvial fan deposits, but are generally not capped and are deeply incised.

Figure 3. Exposure of coarse, carbonate-cemented QTa gravel deposits above much finer Tqs Quiburis Formation deposits; deposits are separated by an obvious erosional unconformity.

Basin Fill Deposits

Tqc **Late Miocene to Pliocene Quiburis deposits, conglomeratic facies** - Sandy conglomerate, conglomeratic sandstone, some sandstone, rare mudrock. Generally very light gray and moderately to strongly indurated. Outcrops of Tqc weather moderately to well rounded. Sand is poorly sorted, angular, medium grained to granule sand, with abundant disaggregated granite particles of quartz or feldspar. Clasts in conglomerate typically include significant percentage of Oracle granite, also Cloudburst volcanics, and sparse Apache group clasts. Percentages of granite and volcanics vary as much as 50% depending on location and proximity to source terrain. Bedding generally massive yet distinguishable by grain size variations, locally by parting between beds. Tqc overlies the playa facies in sharp contact, most noticeably near cliffs, along the west and east basin margins, interpreted to be a progradational event. Tqc deposits are characterized by completely indurated (stage III-IV) sections of Quiburis basin fill sediments. Portions of these deposits are clast supported while others are completely calcium carbonate matrix supported.

Tqs **Late Miocene to Pliocene Quiburis deposits, fan toe and axial valley facies** - Sandy fan-toe, lake-margin, and delta-front sandflat facies (massive to laminated sandstone with minor shale or mudstone interbeds and local thin pebble stringers) intermediate in both grain size and depositional environment between laterally equivalent alluvial-fan/braidplain (Tqc) and lacustrine (Tql) facies.

Tql **Late Miocene to Pliocene Quiburis deposits, lacustrine facies** - Laminated lacustrine facies includes interbedded mudstone, limestone, gypsum, and diatomite beds of varying thickness, with sparse and thin intercalations of laminated lacustrine sandstone. Diatomite beds range from 20cm to 1.5m thick. Where diatomite beds interbedded with siltstone dominate this facies exhibits a characteristic white outcrop color, although silt and mud commonly coat outcrop surfaces. Diatomite beds are resistant to weathering and commonly form cliff-slope-cliff topography. Relatively softer beds are composed of a mix of mudstone, siltstone, and limestone. Rare beds of soft, unconsolidated volcanic ash are preserved best underlying resistant beds of gypsiferous siltstone and diatomite. Insects commonly burrow in the volcanic ash layers. Laminated lacustrine facies includes interbedded mudstone, limestone, gypsum, and diatomite beds of varying thickness, with sparse and thin intercalations of laminated lacustrine siltstone and rare sandstone.

Tqd **Late Miocene to Pliocene Quiburis deposits, diatomaceous facies** - Bedded diatomaceous facies includes medium to thick beds of diatomite interbedded with mudstone, limestone and sparse lacustrine sandstone. Diatomite beds range from 20cm to 1.5m thick. Diatomite beds interbedded with siltstone exhibit a characteristic white outcrop color. Diatomite beds are fairly resistant to erosion, and commonly alternate with relatively softer beds that are composed of a mix of mudstone, siltstone, and limestone.

BEDROCK MAP UNITS

Oligocene to lower Miocene volcanic units

Tgv **Galiuro volcanics (Oligo-Miocene)** - Fine-grained volcanic rocks exposed east of the San Pedro River.

Paleozoic sedimentary units

IPh **Horquilla Limestone (Pennsylvanian) –** Light to medium gray limestone and interbedded silty limestone, in beds 30-60 cm thick (from Creasey, 1967).

Me **Escabrosa Limestone (Mississippian) –** Pale gray limestone, thick bedded to massive, commonly with sparse to abundant siliceous stringers and chert nodules. Limestone is generally a grainstone, composed of small fossil fragments, including locally abundant crinoid columnals and sparse columns composed of multiple columnals. Silty limestone is present locally. Bedding is defined by elongate chert nodules and stringers, color variations, and composition variations (e.g., silty vs. non-silty). Solitary coral fossils are locally abundant (Figure 4). Correlation of this unit with Mississippian Escabrosa Limestone is based on its thick bedded nature rather than thin bedded and more commonly silty as with Pennsylvanian Horquilla Limestone (Creasey, 1967). It is also dissimilar to the Pennsylvanian to Permian Earp Formation which typically includes silty or sandy carbonate or beds of fine sandstone.

Ꞓb **Bolsa Quartzite (Cambrian) –** One small outcrop area of Bolsa Quartzite was identified by Dickinson (1998) on the east side of the San Pedro River. This unit generally consists of fine- to medium-grained, plane bedded to cross bedded sandstone.

Proterozoic(?) granitoid units

TXfg **Fine-grained granite (Proterozoic or Laramide [upper Cretaceous or lower Tertiary])** - Granitoid containing 40%, 1-3 mm white plagioclase and 4-8%, <1 mm biotite, and 1-2%, <1 mm quartz.

Yo **Oracle Granite (Mesoproterozoic) –** Porphyritic, medium- to coarse-grained biotite granite. Microcline phenocrysts are as large as 2 x 4 cm and somewhat poikilitic, with included mafic minerals imparting a speckled appearance. K-feldspar is commonly pink to reddish, and mafic minerals are generally abundant (7-12%). [Speckled, poikilitic, reddish to pink K-feldspar megacrysts and abundant mafics dominated by aggregates of fine biotite are characteristic of Oracle Granite that are commonly used as criteria for tentative correlation]. Similar granite in the Samaniego Hills, 75 km to the west-southwest, has been dated by U-Pb zircon at 1434.5 ± 3.4 Ma. Two-mica granite at Black Mountain, located 45 km to the west-northwest and interpreted as a phase of Oracle Granite, has been dated by U-Pb zircon at 1433.5 ± 2.1 Ma (Spencer et al., 2003). This is the inferred to be the age of the Oracle Granite.

Figure 4. Coral fossils in the Mississippian Escabrosa Limestone. Scale bar is 1 cm, dots in mm.

REFERENCES CITED

Creasey, S.C., 1967, General geology of the Mammoth Quadrangle, Pinal County, Arizona: U.S. Geological Survey Bulletin 1218, 94 p., plate 1 scale 1:48,000.

Dickinson, W.R., 1987, General geologic map of Catalina core complex and San Pedro trough, Arizona: Arizona Geological Survey Miscellaneous Map MM-87-A, 15 sheets, scale 1:62,500, with 18 p. text.

Dickinson, W.R., 1991, Tectonic setting of faulted Tertiary strata associated with the Catalina core complex in southern Arizona: Geological Society of America, Special Paper 264, 106 p.

Dickinson, W.R., 1998, Facies map of post-mid-Miocene Quiburis Formation, San Pedro trough, Pinal, Pima, Gila, Graham, and Cochise Counties, Arizona: Arizona Geological Survey Contributed Map CM-98-A, Ten sheets, scale 1:24,000, with 6 p. text.

Dickinson, W.R., 2003, Depositional facies of the Quiburis Formation, basin fill of the San Pedro trough, southeastern Arizona Basin and Range Province, *in* Raynolds, R.G., and Flores, R.M., eds., 2003, Cenozoic systems of the Rocky Mountain region: Denver, Rocky Mountain Section, SEPM (Society for Sedimentary Geology), p. 157-181.

Hereford, R., 1993, Entrenchment and widening of the upper San Pedro River, Arizona: Geological Society of America Special Paper 182, 46 p.

Huckleberry, G., 1996, Historical channel changes on the San Pedro River, southeastern Arizona (revised October 1996): Arizona Geological Survey Open-File Report 96-15, 22 p.

Pearthree, P.A., McKittrick, M.A., Jackson, G.W., and Demsey, K.A., 1988, Geologic map of Quaternary and upper Tertiary deposits, Tucson 1º x 2º Quadrangle, Arizona: Arizona Geological Survey Open-File Report OFR-88-21, scale 1:250,000.

Spencer, J.E., Isachsen, C.E., Ferguson, C.A., Richard, S.M., Skotnicki, S.J., Wooden, J., and Riggs, N.R., 2003, U-Pb isotope geochronologic data from 23 igneous rock units in central and southeastern Arizona: Arizona Geological Survey Open-File Report 03-08, 40 p.

Wood, M.L., 1997, Historical channel changes along the lower San Pedro River, southeastern Arizona: Arizona Geological Survey Open-File Report 97-21, 44 p., 3 sheets, scale 1:24,000.