Preliminary stratigraphic interpretations of the Soledad Rojo formation in the lower Colorado River Extensional Corridor, western Palo Verde Mountains, southeastern California

Bryan P. Murray & Abdulla Al-kaabi

Department of Geological Sciences, California State Polytechnic University, Pomona

Abstract

This study presents preliminary geologic mapping, stratigraphy, and provenance data from the "Soledad Rojo formation", an informal name given by previous workers to a moderately east-dipping section of early Neogene(?) pre-Bouse Formation red beds on the western side of the northern Palo Verde Mountains of southeastern California. This unit has been correlated to the Tolbard Fanglomerate located ~13 SW of the study area, which was likely deposited during early Miocene extensional deformation in the lower Colorado River region; however, this association is uncertain due to the lack of depositional age controls and the geographic distance between these two formations.

The Soledad Rojo formation likely represents deposition in adjacent alluvial fan and braided fluvial systems in a normal fault basin that developed during regional early Neogene extension. This basin is bounded by Oligocene-age intermediate volcanic rocks of the Palo Verde Mountains to the east, and the late Oligocene tuff of Black Hills to the west. The base of the formation is generally not exposed; however, in one locality it overlies a welded tuff that is similar in appearance to the tuff of Black Hills. Our study subdivides the formation into three stratigraphic units: 1) a lower alluvial unit, consisting primarily of trough cross bedded brick red coarse-grained lithic arkose and granule-pebble conglomeratic sandstone, interbedded with matrix- and clast-supported, subangular-subrounded, moderate-poorly sorted cobble conglomerate with meta-plutonic and volcanic clasts; 2) a middle fluvial unit of clast-supported, imbricated, rounded-subrounded, moderate-well sorted, cobble-boulder conglomerate with primarily meta-plutonic clasts, interbedded with brick red lithic arkose similar to lower unit; and 3) an upper alluvial unit of light gray-buff conglomeratic lithic arkose and interbedded matrix- and clast-supported pebble-cobble conglomerate with subangular-subrounded meta-plutonic and volcanic clasts. In the northern study area, bimodal volcanic rocks are intercalated in the section. Following (and possibly during) deposition, the Soledad Rojo formation was extended and gently tilted east by NW-trending, W-dipping normal faults. In the northern part of study area, a younger dacitic intrusion crosscuts the tilted section.

Geologic Setting

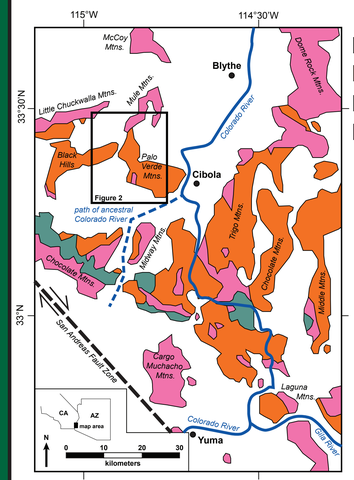


Figure 1 (left): Regional geologic map of southeastern California & southwestern Arizona, showing the distribution of early Neogene volcanic & sedimentary deposits (orange) and potential basement sediment source rocks, including Precambrian-Mesozoic metaigneous & metasedimentary rocks (pink) and the Orocopia schist (green). The proposed path of the ancestral Colorado River is indicated by blue dashed line south of the Palo Verde Mountains (modified from Sherrod and Tosdal, 1991). The location of the study area is indicated by the black box (Fig. 2); the Tolbard Fanglomerate, which is tentatively correlated to the Soledad Rojo formation, outcrops in the Midway Mountains ~13 km to the south

- Holocene - late Miocene sedimentary deposits
- Oligo-Miocene (ca. 32-18 Ma) volcanic & sedimentary deposits - includes minor Tertiary granites
- Orocopia schist (Mesozoic) - includes Mesozoic & Tertiary granitic rocks in western Chocolate Mtns.
- Metaigneous & metasedimentary rocks (Mesozoic-Proterozoic)

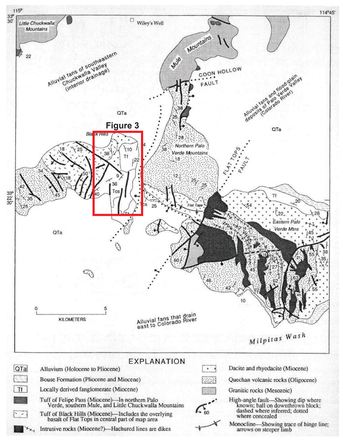
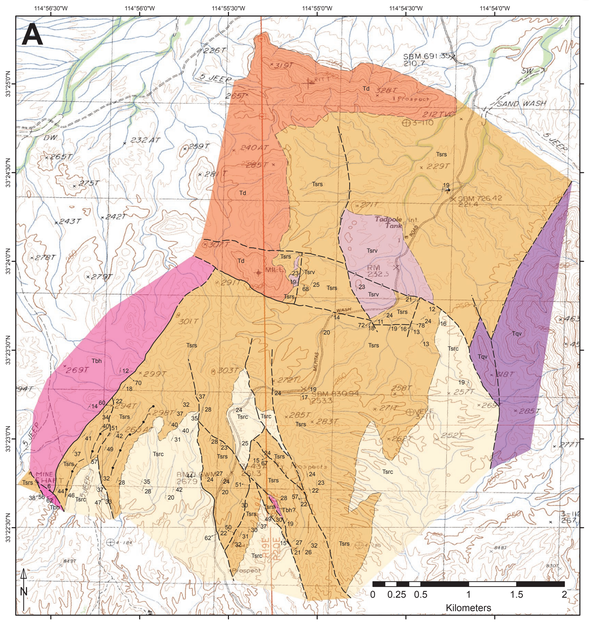
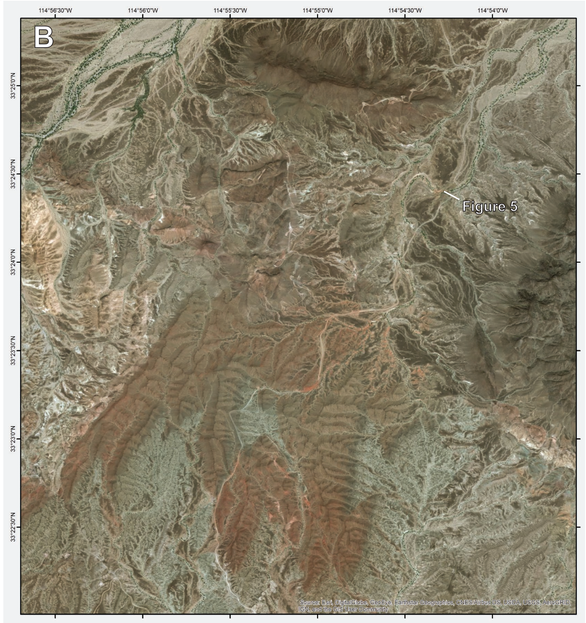


Figure 2 (right): Simplified geologic map of the Palo Verde Mountains & Black Hills (from Sherrod and Tosdal, 1991). Map units Tcs, undefined in the explanation, and Tf in the Black Hills and northern Palo Verde Mountains correspond to the Soledad Rojo formation (an informal formation name proposed by Elliot and Marshall, 2011). The red box indicates the location of Figure 3.

Geologic Map





Lithologic Units

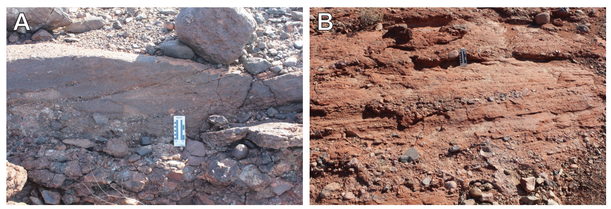
- Td - "Mill" dacitic intrusion
- Tsrc - Soledad Rojo fm., light gray conglomerate & sandstone
- Tsrs - Soledad Rojo fm., reddish-orange sandstone & conglomerate
- Tsrv - Soledad Rojo fm., mafic lava & silicic tuff
- Tbh - Tuff of Black Hills (late Oligocene-early Miocene)
- Tqv - Quechan Volcanics (late Oligocene-early Miocene)

Symbols

- Strike & dip of bedding
- Approximate strike & dip of bedding
- Strike & dip of lava flow banding
- Strike & dip of ignimbrite compaction foliation
- Dip & dip direction of fault plane
- Trend & plunge of slickenlines
- Rounded, clast-supported conglomerate
- Contact - certain
- Contact - approximately located
- Fault - certain
- Fault - approximately located
- Fault - queried

Figure 3 (above): Geologic map (A) and satellite image (B) of the Soledad Rojo basin in the western Palo Verde Mountains/Black Hills. The Soledad Rojo formation in the basin are gently-moderately (~20-45°) tilted towards the east, and are offset by several NNW-striking, W-dipping normal/oblique faults. The basin is bounded on the east by a poorly exposed NE-striking, NW-dipping normal fault, with the late Oligocene-Miocene (ca. 18-26 Ma) Quechan Volcanics in the footwall. The west side of the basin is bounded by a NE-striking, SE-dipping normal fault with the Oligo-Miocene (ca. 22-28? Ma) Tuff of Black Hills in the footwall (age data from Sherrod and Tosdal, 1991, and references therein). At one locality within the southern part of the map area, the Soledad Rojo formation is deposited unconformably upon a welded ignimbrite interpreted as the Tuff of Black Hills. The location of the Tadpole Tanks measured section (Fig. 5) is shown on Figure 3B.

Field Photographs



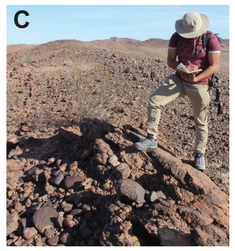


Figure 6 (above & left): Photos of Soledad Rojo formation reddish-orange sandstone/conglomerate unit (Tsrs). (A) Trough cross-bedded conglomeratic sandstone, filling a channel scour in underlying cobble conglomerate. Restored channel axis indicates westward (291°) flow. (B) Trough cross-bedded sandstone with interbedded pebble-cobble conglomerate lenses. Clasts are generally subangular with metamorphic, plutonic, & mafic-silicic volcanic compositions. (C) Clast-supported cobble-boulder conglomerate with rounded metamorphic, plutonic, & ± volcanic clasts (marker bed in Fig. 3A), interbedded with sandstone

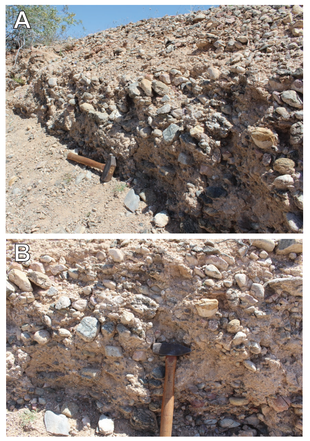


Figure 7 (right): Photos of Soledad Rojo formation light gray conglomerate/sandstone unit (Tsrc). (A) Clast-supported polymictic cobble conglomerate with subangular-subrounded imbricated clasts. (B) Close-up of outcrop in photo A, showing the metamorphic, plutonic, & mafic-silicic volcanic clast compositions with light gray silty-sand matrix

Figure 8 (above): Panoramic photograph looking NE at the western margin of the Soledad Rojo basin. The hill near the center of the photograph consists of a resistant welded ignimbrite (tuff of Black Hills), which overlies white tuffaceous volcaniclastic rocks in the low-lying area to the west. East of the central hill is the basin-bounding SE-dipping normal fault, with E-dipping red Soledad Rojo formation sedimentary rocks in the hanging wall to the east.

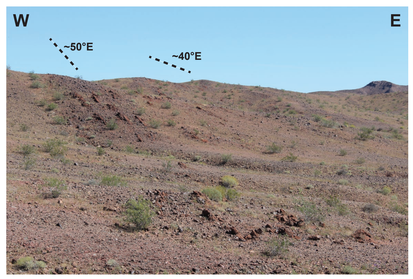
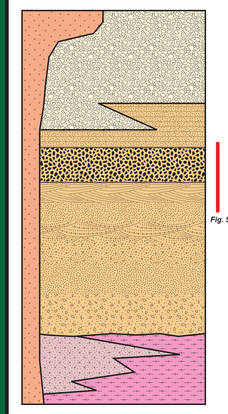


Figure 9 (left): Possible growth strata (fanning bedding dips) in the the Soledad Rojo formation, suggesting synextensional deposition. Dark red sandstone on left dips ~50°E, which is overlapped by lighter red sandstone dipping ~40°E near center of photograph.

Stratigraphy

Figure 4: Solodad Rojo formation generalized stratigraphy



Td: light red dacitic intrusion: aphanitic groundmass, 5-10% biotite & plagioclase phenocrysts, small (<1 cm) gray volcanic xenoliths

Tsrc: light gray pebble-cobble conglomerate: matrix-supported (locally clast-supported), poorly sorted, subangular-subrounded clasts of metamorphic/plutonic basement & mafic-silicic volcanics (*debris flow deposits*); light gray/tan medium-very coarse grained arkosic sandstone & conglomeratic sandstone: moderately-poorly sorted, subangular-subrounded, with thin granule conglomerate lenses (*braided fluvial deposits*). 450+ m-thick

Tsrs: red medium-coarse grained arkosic sandstone & conglomeratic sandstone: moderately sorted, subangular-subrounded, trough cross-bedded, horizontal laminated, channel scours, and massive, with thin granule-pebble conglomerate lenses (*braided fluvial deposits*); red matrix-supported pebble-small boulder conglomerate: poorly sorted, subangular-subrounded (locally angular), clasts of mafic-silicic volcanics & metamorphic/plutonic basement (*debris flow deposits*). Upper section consists of red clast-supported cobble-boulder conglomerate: rounded-subrounded, imbricated metamorphic/plutonic basement ± mafic-silicic volcanic clasts, interbedded with medium-coarse grained sandstone lenses (*braided fluvial deposits*). 400+ m- thick

Fig. 5

Tsrv: basal bimodal volcanic rocks: gray, vesicular, flow-banded basaltic lava with 10-15% olivine (to 2 mm) & plagioclase phenocrysts; tan rhyodacitic tuff with 5% biotite, quartz, & plagioclase phenocrysts, trace gray volcanic lithic fragments; interbedded volcaniclastic granule-pebble conglomerate. 200+ m-thick

Tbh: Tuff of Black Hills (welded ignimbrite): light red-orange groundmass, dark gray fiamme (becomes white pumice upsection), 5-10% biotite, sanidine, & quartz phenocrysts, reddish-gray silicic volcanic rock fragments (to 1 cm)

Figure 5: Tadpole Tanks measured stratigraphic section

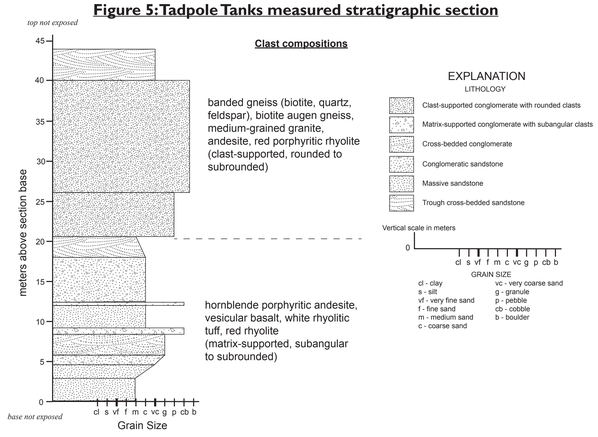


Figure 4 (top): Generalized stratigraphic column of the Solodad Rojo formation, describing the key characteristics, depositional environment interpretations, and the approximate thickness of the mapped rock units in the study area (Fig. 3). The red bar roughly corresponds to the stratigraphic position of the Tadpole Tanks measured section (Fig. 5).

Figure 5 (above): Measured stratigraphic section of the Solodad Rojo formation near Tadpole Tanks (Fig. 3B). Dashed line indicates the boundary between rounded-subrounded clast-supported cobble-boulder conglomerate above (marker bed in Fig. 3A) and subangular-subrounded sandstone & matrix-supported conglomerates below.

Preliminary Interpretations

- The Solodad Rojo formation was primarily deposited in a proximal-medial alluvial fan system that developed in a normal fault basin.
- Sediment in the alluvial fan deposits was mainly derived from the metaplutonic basement & mafic-silicic volcanic rocks exposed in the areas adjacent to the basin; however, the different textures and clast compositions of the rounded conglomerate layer (Fig. 5) suggest it may have been derived from more distal sources transported into the basin by incursion of a moderate-energy fluvial system.
- Growth strata suggests synextensional deposition of the Solodad Rojo formation, with main downdropping on the eastern side of basin.
- Bimodal volcanic rocks at the base of the formation and post-depositional dacitic intrusions also suggests coeval extension and magmatism (samples have been submitted for $^{40}Ar/^{39}Ar$ geochronology to constrain depositional timing)
- Future work will consist of sandstone point-counting, conglomerate clast counts, and detrital zircon U-Pb dating to further constrain the provenance of basin sediments
- A detailed sedimentological comparision of the Solodad Rojo formation to the Tolbard Fanglomerate in the Midway Mountains will determine if the proposed correlation of these units is valid.

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REFERENCES CITED:

Elliot, W.J., and Marshall, M., 2011, In search of Colorado River "B" gravel, northeastern Imperial County, California, with notes on Early Tertiary red beds *in* Wirths, T.A., ed., Picacho and the Cargo Muchachos: gold, guns, and geology of eastern Imperial County, California, 2nd edition: San Diego Association of Geologists, p. 183-193.

Sherrod, D.R., and Tosdal, R.M., 1991, Geologic setting and Tertiary structural evolution of southwestern Arizona and southeastern California: Journal of Geophysical Research, v. 96, no. B7, p. 12407-12423.