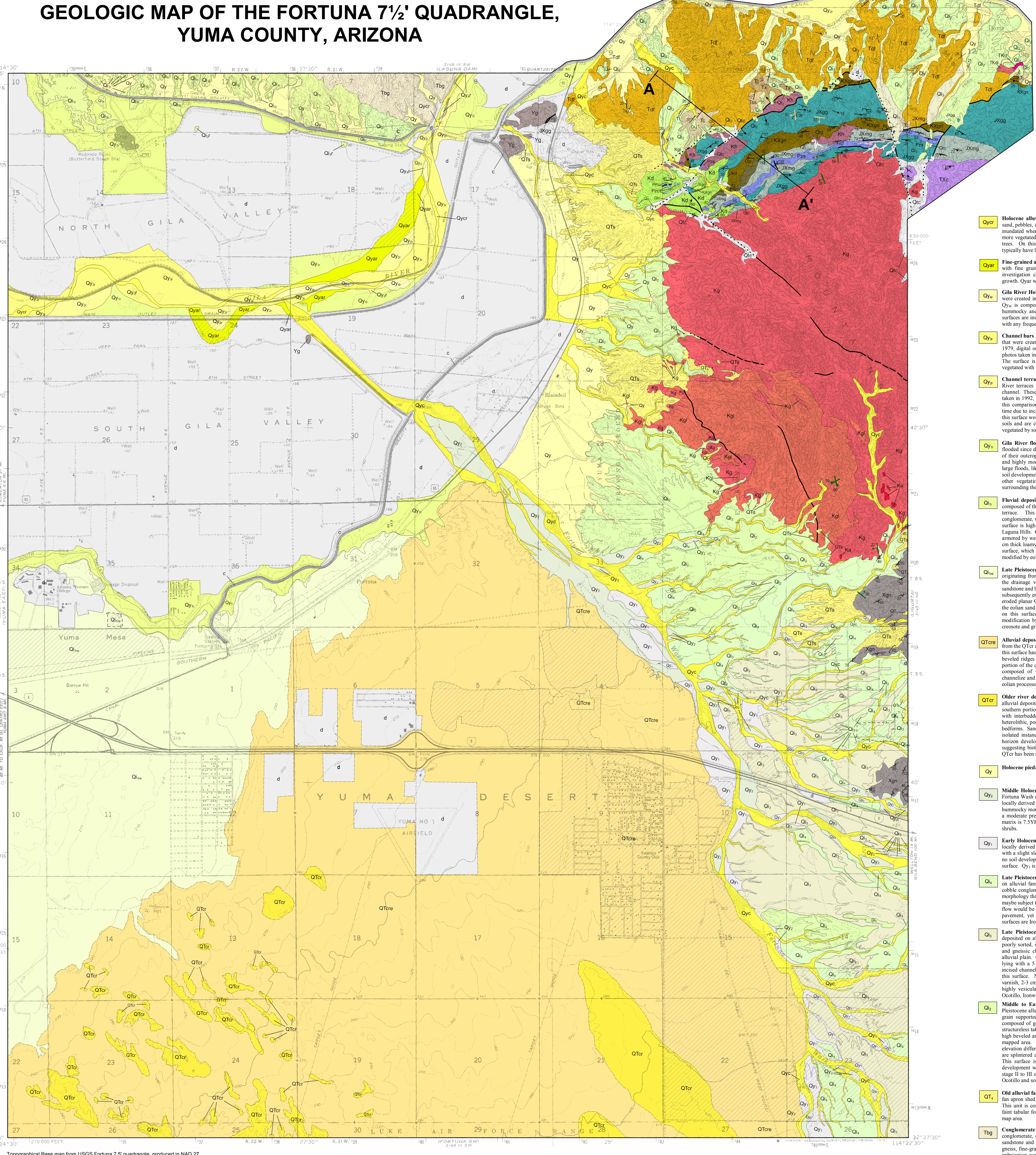
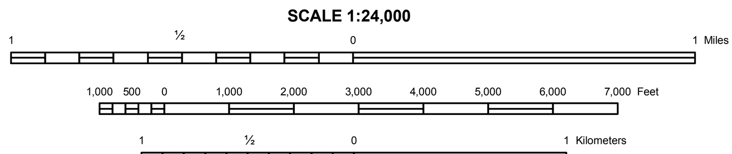
GEOLOGIC MAP OF THE FORTUNA 7½' QUADRANGLE, YUMA COUNTY, ARIZONA

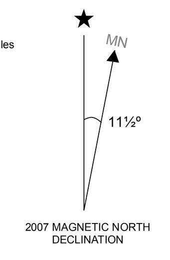


Topographical Base map from USGS Fortuna 7.5' quadrangle, produced in NAD 27.
Projection: reprojected to NAD83; Latitude-longitude and UTM grids are NAD 83, UTM Zone 11.
Magnetic declination 11½° east of true north.

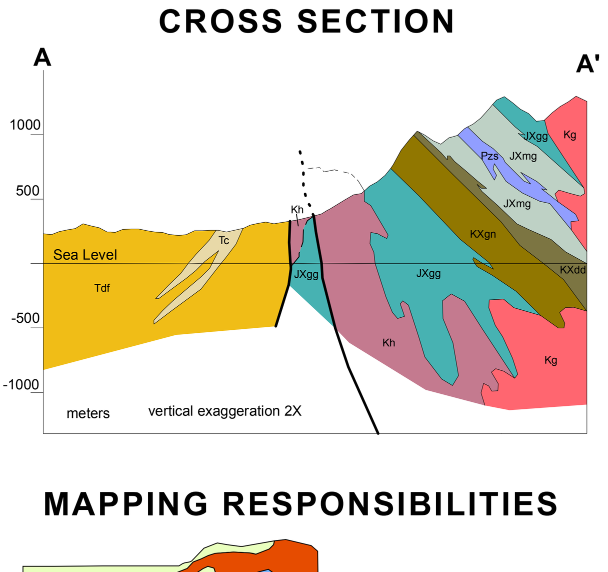
SCALE 1:24,000



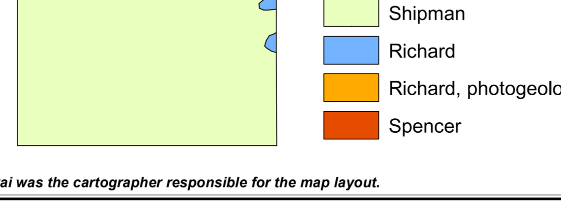
contour interval 20 feet



CROSS SECTION



MAPPING RESPONSIBILITIES



Stevan Gyetvai was the cartographer responsible for the map layout.

EXPLANATION OF POINT SYMBOLS

Bedding
- bedding, inclined
- bedding, inclined, approximate
- apparent dip

Igneous features
- Pegmatite dike

Foliation, Tectonic
- Unclassified tectonic foliation
- inclined gneissic foliation
- vertical gneissic foliation
- transposed bedding, inclined
- close disjunct cleavage, inclined
- weak protomylonite
- protomylonite
- Mylonite, showing stretching lineation in foliation
- Penetrative lineation, 'l'-tectonite
- fault attitude
- mineralized vein

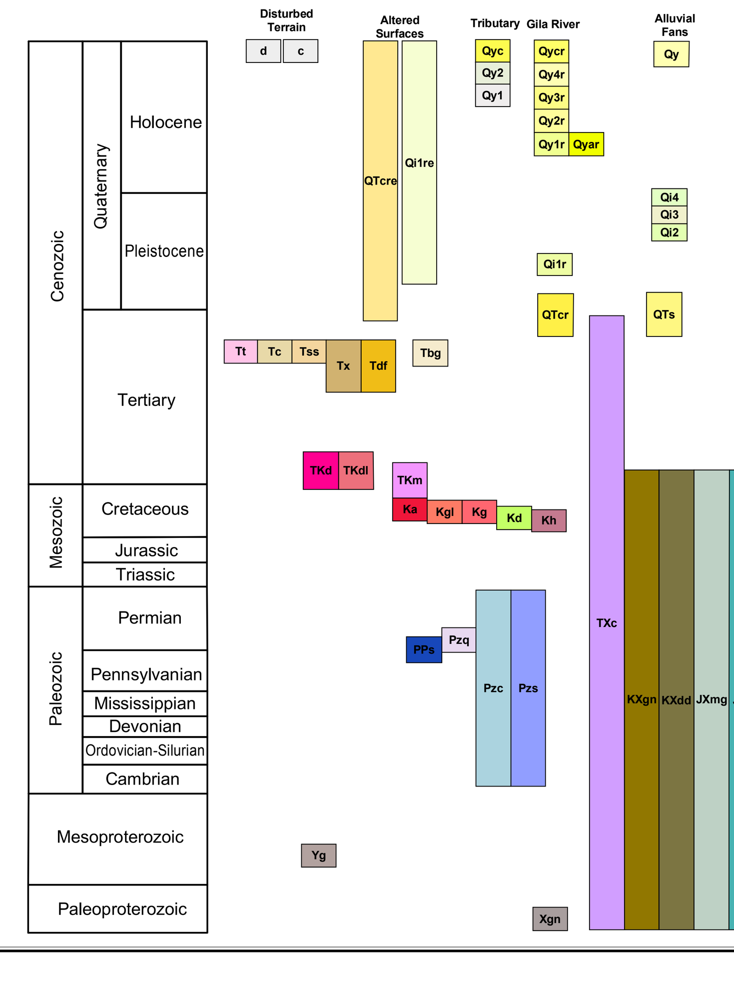
EXPLANATION OF LINE SYMBOLS

Contacts
- Gradational contact
- approximate contact
- accurate contact
- scratch contact
- queried dashed contact

Faults
- Fault, accurate
- Fault, approximate
- Fault, approximate, hypothetical

Areas in which geology predating surface development is shown on map.

CORRELATION OF MAP UNITS



GEOLOGIC UNITS

c — **Canals developed for agriculture**

d — **Surface deposits related to human activity (Recent)** – Areas of significant recent surficial disruption due to various human activities. Includes dams, sand and gravel quarries, large cattle tanks, areas leveled for mining and other development activity, etc.

Qtc — **Colluvium and talus** – Unconsolidated to moderately consolidated colluvium and talus deposits on hill slopes. These hill slope deposits are typically weakly bedded, subangular to angular, poorly sorted silt to boulders. Underlying bedrock lithology determines clast composition.

Qyc — **Late Holocene active channel deposits (present)** – Unit Qyc includes only active, open channels of tributary washes on the piedmonts that could be delineated at a scale of 1:24,000. This unit is composed of moderately-sorted sand, gravel, and pebbles with some cobbles in the lower piedmont areas to poorly-sorted sand, gravel, pebbles, and cobbles in the upper piedmont areas. Channels are generally incised less than 0.5 to 1 meter below adjacent Holocene terraces. Channel morphologies generally consist of a single thread deep high flow channel or multi-threaded shallow low flow channels with adjacent gravel bars. The channels are flood prone and are subject to deep, high velocity flow during moderate to large flood events. Channels are subject to scouring and bar deposition. Banks are subject to lateral erosion. There is no soil development in this active fluvial unit, and little or no vegetation within the channels.

Qycr — **Holocene alluvium, younger deposit (<100 yrs.)** – These deposits are composed of unconsolidated sand, pebbles, and cobbles. Located within the active drainage of the Gila River these deposits are often inundated when flooding occurs. Locally exhibits bar and swale topography, the bars being typically more vegetated. These surfaces are typically dominated by grasses and small shrubs or young mesquite trees. On this surface the main channel commonly diverges into braided channels. These surfaces typically have little to no soil development.

Qyar — **Fine-grained alluvium in abandoned river channels** – Abandoned pre dam (1959) river channels filled with fine grained sediment. Qyar was identified and mapped by air photo. Only a peripheral site investigation could be conducted because these areas have been choked by impenetrable tamarisk growth. Qyar would be inundated during large flooding events.

Qy_{4r} — **Gila River Holocene alluvium deposit (<100 yrs)** – Unit Qy_{4r} is composed of Gila River sandbars that were created in the 1993 flood. Since that flood there has been no major event to shift these deposits. Qy_{4r} is composed of loamy sand, with some gravel bars and no soil development. The surface is hummocky and has channelized flow due to the bars and swales. During moderate flooding these surfaces are inundated, however flooding on the Gila is controlled by series of dams and does not flood with any frequency. Qy_{4r} is sparsely vegetated with some grasses.

Qy_{3r} — **Channel bars and floodplain younger than 1993 flood** – Unit Qy_{3r} is composed of Gila River terraces that were created in the 1993 flood. These deposits were mapped using BLM aerial photos taken in 1979, digital orthographic photos taken in 1992, and compared with digital orthographic photos taken photos taken in 1996. Qy_{3r} is composed of loamy sand, with some gravel bars and no soil development. The surface is hummocky and has channelized flow due to the bars and swales. Qy_{3r} is sparsely vegetated with some grasses and shrubs.

Qy_{2r} — **Channel terraces in 1979 before 1993 flood (1979 and younger)** – Unit Qy_{2r} is composed of Gila River terraces that was the active floodplain in 1979 and has deposited within the incised Gila River channel. These deposits were mapped using BLM arial photos taken in 1979, digital orthographic photos taken in 1992, and compared with digital orthographic photos taken photos taken in 1996. Based upon this comparison the photos units were defined as the pre-flood floodplain, which has change through time due to incision and flood control from the Painted Rock Dam. Due to the proximity to the channel this surface would be inundated during a moderate flood event. Qy_{2r} surfaces have little to no developed soils and are composed of 10YR 5/3 loamy sand, with little to no channelized flow. The surface is vegetated by some tamarisk, crow screw bean mesquite, and arrowweed.

Qy_{1r} — **Gila River floodplain not flooded since 1959** – Deposits of the Gila River floodplain that has not flooded since dam construction in 1959, which were and are currently modified by agriculture over most of their outcrop. Exposures of these deposits are topographically elevated near the Gila River channel and highly modified by eolian processes. This surface may be subject to inundation during especially large floods, like the floods in 1993. Qy_1r is composed of loamy sand, 10YR 6/3, and the reis little to no soil development. Where not cultivated, Qy_{1r} is dominated by extremely large creosote bushes with little other vegetation. Due to the modification by eolian processes, the surface has mounds of sand surrounding the large vegetation which creates a hummocky surface.

Qi_{1r} — **Fluvial deposits of Yuma Mesa (~50 to 100 ka)** – Unit Qi_{1r} is composed of an alluvial sequence composed of three facies 150 ft to 200 ft thick, most likely interpreted as Gila/Colorado River floodplain terrace. This deposit is composed of three facies; fine grained, sandstone/siltstone, and pebble conglomerate, which vary laterally along the exposures along the southern base of the Laguan Hills. Qi_{1r} surface is highly beveled with pervasive degradation, the base of the surface abuts to the base of the Laguna Hills. Qi_{1r} is 100 ft above the Gila River and would not flood in the largest event. The surface is armored by well rounded pebbles creating a moderate desert pavement with moderate varnish and a >1 cm thick loamy layer. This surface is vegetated by some grasses. Associated with this surface is a Qi_{1re} surface, which has been referred to as the "Yuma Mesa", the same deposit which has been subsequently modified by eolian process in the southern portion of the mapped area.

Qi_{1re} — **Late Pleistocene fluvial to alluvial deposits (~50 to 100 ka)** – Fluvial to alluvial deposits, most likely originating from the Colorado River. Presently this surface has undergone erosion and modification of the drainage valleys by eolian processes. This alluvial package is composed of gravelly channel sandstone and bars. Qi_{1re} represents the eroded surface of Colorado/Gila River alluvial deposits that have subsequently eroded. The sandy detritus eroded from the QTcr unit, adjacent to the Qi_{1re} surface, covers eroded planar Qi_{1re} surface that is < 3 meters below the QTcre surface. High porosity, characteristic of the eolian sand, of the surface deposits prevents surface flow along the drainages. Channel development on this surface is masked by the infiltration of the surface flow into the sands and subsequent modification by the eolian processes. There is no soil development and the surface is dominated by creosote and grasses

QTcre — **Alluvial deposits contained within valleys incised into QTcr** – Unit QTcre is eolian deposits eroded from the QTcr and redeposited within the alluvial drainages that were excavated into the QTcr. Presently this surface has undergoing erosion and modification of the drainage valleys by eolian processes. Highly beveled ridges and mounds punctuating the surface, produces most of the topography in the southern portion of the quad. These mounds represent the interfluve edifice that is the QTcr deposits. QTcre is composed of well sorted loamy sands. During moderate to extreme precipitation these valleys channelize and develop some drainage network, however these networks are subsequently wiped out by eolian processes.

QTcr — **Older river deposits of Upper Mesa (Quaternary to Late Tertiary)** – Unit QTcr is Colorado River alluvial deposit, which have been eroded and make up the topographically elevated mesa and hills in the southern portion of the mapped area. QTcr is composed of grain and matrix supported conglomerates with interbedded sandstone and mudstone. Cobble and pebble clasts are well rounded to rounded, heterolithic, poorly sorted, in most cases the conglomerates are encased in cement, with tabular to scoop bedforms. Sandstones are well-sorted, fine to very fine arkosic sands. Soil is rare and only preserved in isolated instances where fine grain material still exists. Soil are fine grain, no evidence of peds or horizon development present, loamy sand, 10YR 7/4, cemented with CaCO3, some vertical burrows suggesting bioturbation. Highly beveled ridges and mounds are where the best outcrops are exposed. QTcr has been mined for its gravel deposits. This surface is sparsely vegetated by creosote and grasses.

Qy — **Holocene piedmont alluvium, undivided** – Mostly alluvium, may include some eolian deposits.

Qy_2 — **Middle Holocene (<1000 yrs)** – Unit Qy_2 is composed of vegetated channel bars located within the Fortuna Wash and other tributaries shedding off the Gila Mountains. Qy_2 is composed of poorly sorted locally derived granite and gneissic sandy conglomerate. Channel bar surfaces are not incised and have a hummocky morphology approximately 0.5 m above the active channels. Qy_2 would be overtopped with a moderate precipitation event. These surfaces are young and have not developed soils, however the matrix is 7.5YR 7/4 and contains some amounts of calcium carbonate. Qy_2 is vegetated by grasses and shrubs.

Qy_1 — **Early Holocene alluvial terrace** – Unit Qy_1 alluvial terraces are related to the Fortuna Wash. Qy_1 is locally derived loamy sand with some locally derived cobble conglomerate lenses. The surface is flat with a slight slope toward the Fortuna Wash, with no incision or channelized drainage. Qy_1 has little to no soil development yet the upper surface has a vesiculated horizon. Qy_1 is <2 m above the active Qyc surface. Qy_1 is vegetated by creosote and grasses.

Qi_4 — **Late Pleistocene alluvium (~10 to 20 ka)** – Unit Qi_4 composed of late Pleistocene alluvium deposited on alluvial fans shedding off the Gila Mountains. Qi_4 is a locally derived grain supported pebble to cobble conglomerate, which is composed of granite and gneissic clasts. This surface has a hummocky morphology that is 1 m lower than the Qi_3 surface and .5 m higher than the active channels. Qi_4 surface maybe subject to inundated during especially large floods, however due their hummocky morphology the flow would be mostly channelized. There is no soil development on this surface and little to no desert pavement, yet some cobbles have secondary carbonate pedants. The dominate vegetation on these surfaces are Ironwood trees and some shrubs.

Qi_3 — **Late Pleistocene alluvium (~13 to 50 ka)** – Unit Qi_3 composed of middle Pleistocene alluvium deposited on alluvial fans shedding off the Gila Mountains. Qi_3 is a locally derived grain supported, poorly sorted, subangular to subrounded, pebble to cobble conglomerate, which is composed of granite and gneissic clasts. This surface has lobate morphology, with eroded remnants jutting out into the alluvial plain. Qi_3 is punctuated by incised channels that are clay-loam fill. Generally the surface is flat lying with a 5 degree incline toward the mountain front. Flooding on the Qi_3 surface is confined to incised channels, however flow even during a extreme precipitation event would most likely not effect this surface. No soil development with moderate to high level of desert pavement, moderate desert varnish, 2-3 cm thick clay loam, calcium carbonate cementation, stage I to II soil carbonate, 7.5YR 7/4, highly vesicular layer just below the surface. This surface is sparsely vegetated with Ironwood and Ocotillo, Ironwoods resides mainly within the incised drainages.

Qi_2 — **Middle to Early Pleistocene alluvium (~50 to 90 ka)** – Unit Qi_2 composed of middle to early Pleistocene alluvium deposited on alluvial fans shedding off the Gila Mountains. Qi_2 is a locally derived grain supported, poorly sorted, subangular to subrounded, pebble to cobble conglomerate, which is composed of granite and gneissic clasts. In cross section, approximately 1.5 m below the surface are structureless tabular sandstone bodies, composed to medium to coarse grained quartz. The fan surface is high beveled and eroded, only remnants of this surface are preserved in the southwestern portion of the mapped area. Qi_2 is 3-4 m higher than Qi_3. The distinct difference between the Qi_2 and Qi_3 is their elevation difference and the exposed clasts on top of Qi_2 are much more weathered. The surface clasts are splintered and completely decomposed clasts of granite that are unweathered on their buried side. This surface is above most current drainages and is not affected by flooding. Qi_2 has little soil development well-developed desert pavement, well-developed desert varnish, 3-5 cm thick clay loam, stage II to III secondary carbonate, 10YR 7/4, highly vesicular sublayer. This surface is dominated by Ocotillo and some seasonal grasses.

QT_s — **Old alluvial fan deposit (Early Quaternary to Late Tertiary)** – Unit QTs is a highly dissected alluvial fan apron shed off the Gila Mountains, including some isolated patches perched on the mountain side. This unit is composed of granite- and gneiss-clast, pebble to boulder conglomerate, structureless with faint tabular forms. Remnants of this deposit are visible to the crest of the Gila Mountains east of the map area.

Tbg — **Conglomerate (Miocene to Oligocene)** – Weakly bedded to massive, poorly sorted cobble conglomerate, commonly with much sand and silt matrix, and locally including sparse conglomeratic sandstone and sandstone. Clasts 1-100 cm, mostly 2-20 cm, consist primarily of zebra-stripe banded gneiss, fine-grained granitoids, and fine-grained metasandstone(?). Grades into debris-flow unit. Clast imbrication suggests flow to south.

Tc — **Debris-flow deposits (Miocene to Oligocene)** – Massive to very poorly bedded, extremely poorly sorted, matrix-supported debris flows with sub-rounded to sub-angular clasts generally 1-50 cm and rarely up to 3 m. Dominant clast type is thinly layered banded gneiss that makes up 50% of clasts. Other clasts are granitoids and high-grade metamorphic rocks. Tertiary volcanic rock fragments are absent.

Tdf — **Sandstone and conglomeratic sandstone (Miocene to Oligocene)** – Poorly consolidated, poorly sorted siltstone, sandstone, conglomeratic sandstone, and cobble conglomerate. Consists dominantly of pale gray sandstone; immature with biotite grains. Beds are typically 2-20 cm thick and locally fairly well bedded. Popcorn weathering character suggests significant clay content.

Tss — **Tuff (Miocene to Oligocene)** – Moderately indurated and welded, tan, massive tuff, with 10%, 2-20 mm white volcanic lithic fragments, 5-8% lithic fragments of metamorphic and intrusive rocks, and very sparse sanidine. This unit is separated from nearby Tertiary conglomerate and debris flow deposits of the Kinter Formation by a few meters of Quaternary cover, and nearby Kinter Formation does not contain any clasts of this tuff where examined along the wash. However, the tuff is almost certainly interbedded with the conglomerate as is a tuff in the Kinter Formation about 3 km to the northwest in the Laguna Hills (Olmsted, 1972) that has been dated at 24.2 +/- 1.2 Ma (Marvin and Dobson, 1979, K-Ar biotite) and 23.6 +/- 0.06 Ma (40Ar/39Ar sanidine).

Tt — **Rock-avalanche breccia (Miocene to Oligocene)** – Breccia composed of fragments of banded gneiss and quartz-rich metapsammite in both monolithologic and heterolithologic zones.

Tx — **Cobble to boulder conglomerate (Late Tertiary)** – Cobble to boulder conglomerate with a pebble grain matrix, grain supported, 90% of the clasts are composed of a pegmatitic granite, with some chlorite veining. Granite clasts on the surface off this deposits are strongly weathered with fanned splitting and decomposition. Unit dips moderately to steeply to the southeast. Some of unit appears to be rock avalanche breccia; relationship to unit Tx south of the Gila River is uncertain.

TKm — **Crystalline complex (Tertiary to Paloeproterozoic)** – Mixed foliated and unfoliated amphibolite complexly intruded by biotite granite, leucogranite, and pegmatite.

TKd — **Fine-grained dioritic granitoid near Dome, dark phase (Cretaceous or Tertiary)** – Dark, fine-grained dioritic granitoid exposed only in the far northeastern Gila Mountains several hundred meters southeast of Dome.

TKdl — **Fine-grained dioritic granitoid near Dome, light phase (Cretaceous or Tertiary)** – Light colored, fine-grained dioritic granitoid exposed only in the far northeastern Gila Mountains several hundred meters southeast of Dome.contains less hornblende and fewer alkali feldspar phenocrysts.

TXc — **Mafic dikes** – Sparse, dark gray green mafic dikes observed in several parts of the northern Gila Mountains. Rock is fine-grained to very fine-grained plagioclase-hornblende-epidote rock. Dikes intrude units as young as granitic rocks of Blaisdell, but in the granitic gneiss of Avenue 14½ East in the east central part of the Fortuna quad pegmatite dikes cut at least one mafic dike.

Ka — **Aplite and pegmatite (Cretaceous)** – Aplite, occurring mostly as dikes, but in southern part of granitic rocks of Blaisdell dikes have gentle dip and cap hill tops to produce mappable outcrops. Aplite is associated with pegmatite, commonly in the same dike, with layers of aplite in pegmatite dikes. Pegmatite typically contains spotty biotite in 0.5-2 cm flakes. Pegmatite dikes cut Kg granodiorite dikes along southern margin of pluton at east edge of quadrangle. Aplite-pegmatite dikes are mineralogically uninteresting, consisting almost entirely of quartz and feldspar; feldspar appears to be mostly plagioclase. Some feldspar has tooth-like tabular-prism morphology (albite?, white), 1-2 cm by 3-4 cm, with aplite or very fine-grained granite porphyry matrix, these form comb veins locally. Aplite dikes are rarely observed grading into light gray aphanitic felsite dikes.

GEOLOGIC MAP OF THE FORTUNA 7½' QUADRANGLE, YUMA COUNTY, ARIZONA

by Todd C. Shipman, Stephen M. Richard, and Jon E. Spencer

Arizona Geological Survey Digital Geologic Map 55

January, 2007

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Kgl — **Leucogranite, granitic rocks of Blaisdell (late Cretaceous)** – Fine grained, equigranular, texturally variable leucogranite. Leucogranite is fine to medium grained (1-3 mm), <1 to 5% 1-3 mm biotite, 20-30% 1-2 mm quartz, anhedral, equant. In some areas quartz is in 3-6 mm aggregates of small grains. Biotite is commonly associated with epidote; 60-80% feldspar, 1-4 mm plagioclase and alkali feldspar, both white. Locally, a trace of <2 mm diameter garnet is present, but typical leucogranite does not contain garnet. Leucogranite dikes and dikelets intrude adjacent biotite granite of map unit Kg, and inclusions of biotite granite are present within leucogranite near contact. The boundary zone with the biotite granite phase is a mixed zone with abundant irregular interleaving of the two units, visible on the vegetation free hills by the lighter color of the leucogranite bodies. The main body of this phase is characterized by gradations between more and less leucocratic granitoid, as well as variations in the presence and abundance of alkali feldspar phenocrysts. This unit is distinguished from the biotite granodiorite phase because of its lighter color, and it generally contains less hornblende and fewer alkali feldspar phenocrysts.

Kd — **Biotite granodiorite, granitic rocks of Blaisdell (late Cretaceous)** – Medium grained, equigranular, biotite hornblende granodiorite with 4-10% mafic minerals, generally appearing to contain more biotite that hornblende. Typical biotite occurs in black flakes <4 mm in diameter, but locally forms prismatic 'books' up to 1 cm long. Clusters of biotite grains are commonly accompanied by 0.5-1 mm green, equant epidote grains and sparse but ubiquitous honey-colored sphene. Hornblende is black, typically in 2-4 mm long prisms, locally up to 1.5 cm long. Rock contains 10-20% quartz in 1-3 mm anhedral grains and 50-60% plagioclase in 1-3 mm diameter subhedral to anhedral grains. Alkali feldspar in 3-5 mm blocky grains forms about 10% of rock, and 1 cm equant alkali feldspar phenocrysts form 0-5% of rock. Alkali feldspar phenocrysts contain abundant hornblende and biotite inclusions, locally defining growth zones. Variations in the mafic mineral content (color index), biotite to hornblende ratio, and abundance of alkali feldspar phenocrysts on a 10-100 m scale are continuous across the exposed extent of the unit. Granite weathers to form rounded, tan boulders, that are commonly friable on exposed surfaces, with local cavernous weathering. Steep, gravelly slopes on the friable weathered granite make for treacherous footing. A sample of this unit was dated at 74.4 ± 1.3 Ma (U-Pb zircon by LA-ICPMS, University of Arizona). Named for Blaisdell railroad siding along Gila River west of northern end of Gila Mountains. This unit is the main phase of granitic pluton of Blaisdell, which includes ultramafic rocks (hornblendite?) to diorite along border zone at northern end of Gila Mountains, and a light-colored granitic phase in the southern part of the pluton. Boundaries between the phases are mixed gradational zones in almost every case.

Kg — **Diorite to gabbro, granitic rocks of Blaisdell (late Cretaceous)** – Diorite, quartz diorite and probable gabbro along the northwestern border of the granitic pluton of Blaisdell. Rock ranges from non foliated, fine-grained and equigranular to mylonitic, hornblende porphyritic, or coarse grained. Texture and composition variations occur on a meter to decimeter scale, pendants and xenoliths of country rock are common. More strongly foliated rock is generally intruded by non-foliated rock, but strain gradients are apparent in almost every lithologic type. A foliated sample of this unit was dated at 73.4 ± 1.2 Ma (U-Pb zircon by LA-ICPMS, University of Arizona). Southern boundary into the biotite granodiorite phase is gradational over 10's of meters. Boundary with gabbro to hornblendite unit is mapped where coarse-grained ultramafic rocks become predominant.

Kh — **Gabbro to hornblendite, granitic rocks of Blaisdell (Cretaceous)** – Black, fine- to coarse grained hornblendite(?) to gabbro. Black minerals makes up 80% to almost 100% of the rock; mineral grains have typical aspect ratios of 2:1 to 4:1, and are up to 12 mm long. Dominant black mineral appears to be hornblende from hand sample examination, but could be composed of large to dominant fraction of pyroxene. Rock also contains epidote and up to 4%, 1-3 mm biotite. Unit is mostly nonfoliated but is clearly foliated in some areas. Local diorite or perhaps quartz diorite zones are present. Unit is gradational with gabbro-diorite of map unit Kd, which was dated at 73.4 ± 1.2 Ma (U-Pb zircon by LA-ICPMS, University of Arizona). Gradational contacts with the mafic rocks and similar relationships to deformation in the northern Gila Mountains shear zone are the basis for inclusion of this unit in the granitic pluton of Blaisdell.

KXgn — **Biotite augen gneiss of Northern Gila Mountains (Proterozoic or Jurassic protolith, Cretaceous metamorphism)** – Weakly to strongly foliated porphyritic biotite granitoid to augen gneiss. Lacks prominent layering. Least deformed rock is recrystallized, coarse-grained, weakly foliated biotite granitoid with 7-10% biotite in felty aggregates that wrap around feldspar grains. Feldspar (alkali feldspar?) phenocrysts make 20-40% of rock, and are equant, blocky, up to about 3 cm in diameter, typically about 2 cm. Rest of rock is variably sericitized plagioclase and quartz in 2-5 mm diameter equant grain aggregates remnant from original igneous crystals. This is one of the most lithologically homogeneous units in the NorthernGila Mountains shear zone. Locally appears to grade into foliated diorite-granodiorite unit.

KXdd — **Granodiorite to diorite of northern Gila Mountains (Cretaceous, Jurassic or Proterozoic)** – Medium- to fine-grained granodiorite to diorite or gabbro, texturally variable, lens interleaved between biotite augen gneiss and mafic gneisses in southwestern part of northern Gila Mountains shear zone. Rock resembles granodioritic facies of grey gneiss unit, slightly coarser grained. Amphibolite lenses locally separate biotite augen gneiss from the granodiorite, in other places, granodiorite grades to diorite or gabbro, which appears to grade into the augen gneiss, suggesting they are phases of a related plutonic suite. Similar granodioritic rocks occur in mafic gneiss unit adjacent to biotite augen gneiss just southwest of the major north trending canyon at the northeast edge of the quadrangle. Lenses of fine-grained, less foliated granitoid that is slightly lighter colored are present, and similar looking granitoid forms sparse, thin dikes largely postdating foliation in biotite augen gneiss. On the north side of canyon near 743600N 3625000E biotite augen gneiss grades into coarse grained biotite rich granitoid without augen, then into foliated med to coarse grained diorite. This diorite grades up section (to southeast) into fine-grained to medium grained equigranular foliated granodiorite.

JXmg — **Mafic gneiss of northern Gila Mountains** – Heterogeneous assemblage of layered gneiss and foliated intrusive rocks dominated by dark greenish gray to black amphibole-biotite-epidote-feldspar layered gneiss. Composition and texture variation in layered gneiss is suggestive of supracrustal genesis for protolith. Dark colored gneiss locally has possible relict vesicular or fragmental texture suggestive of mafic volcanic origin. The protolith for interlayered, fine-grained quartzofeldspathic layered gneiss was probably associated compositionally immature sedimentary rocks. Intrusive phases range from fine-grained granitoid to gabbro, and are typically at least weakly foliated, locally mylonitic.

JXgg — **Gray gneiss of northern Gila Mountains (Cretaceous to Paleoproterozoic)** – Mostly fine-grained equigranular gray quartz-feldspar-biotite gneiss with amphibolite lenses and metaplutonic appearing granodiorite lenses. Some quartz rich layers (40-70%) may be derived from arkosic sandstone. Fine (<1 mm) biotite makes up 0-7% of rock, and epidote up to 3%. Variably developed fabric ranges from a weak 'l' fabric to weak to moderately developed foliation defined by preferred orientation of biotite and aggregates of quartz or feldspar grains. Lithologic layering is generally weak to almost imperceptible. Unit includes a metasedimentary or metavolcanic facies and a granodioritic facies, which appear to be complexly interleaved and are lithologically similar, precluding map unit distinction. The metasedimentary or metavolcanic facies appears to have been derived from quartz-rich sandstone, rhyolite with very sparse quartz eyes up to 3 mm in diameter, sandstone derived from rhyolite, or a fine grained, felsic granite or leucogranite. Lithologic dissimilarity to all other known Paleozoic and Mesozoic metasandstone in southwestern Arizona suggests that the protolith is Early Proterozoic, but it remains a distinct possibility that the protolith is Jurassic quartz-rich sandstone and/or siltstone, or Jurassic rhyolitic volcanic rocks or clastic sediments derived from rhyolitic volcanic rocks. The granodioritic facies is slightly more biotite rich and generally more homogeneous in character, with relict textures suggestive of a more holocrystalline, fine-grained intrusive igneous protolith. The granodioritic facies is only distinctive when it occurs in large enough masses that the more homogeneous character becomes apparent; the protolith for lithologically identical lithosomes in the metasedimentary/metavolcanic facies may be intrusive or compositionally equivalent supracrustal rocks. Boundaries between the facies are thus gradational and poorly defined, and efforts to map the two facies were abandoned.

Pzs — **Metasedimentary rocks derived from Paleozoic sedimentary rocks (Paleozoic)** – Complexly interleaved tectonitic carbonate and quartzite metasedimentary rocks, including (in no particular order): gray and white calcite(?) marble tectonite; dark varnished calcareous very fine-grained quartzite with 1-10 mm lamination defined by variable resistance to weathering along foliation planes (apparently related to variations in the ratio of silica to carbonate); pale gray fine-grained laminated quartzite with some white mica on parting surfaces; buff orange laminated to medium-thick layered dolomitic-calcareous marble with some siliceous stringers; light gray fine-grained marble with some calcsilicate or siliceous layers; light gray marble; very dark gray weathered, laminated to medium layered epidotic calcareous siliceous sandstone, with micaceous partings (metamorphosed to biotite-quartz-epidote-feldspar laminated; laminated medium to light gray marble. Relatively homogeneous lithosomes within the complex are typically 1-30 m thick, and locally are traceable along strike for 1000's of m. Although the lithologic assemblage is typical of
metamorphosed Paleozoic strata mapped in the Maria fold and thrust belt of west-central Arizona and adjacent California (Reynolds et al., 1986; Richard et al., 1994), the sequencing of units is only locally consistent with that expected in a metamorphosed Paleozoic section. The complex sequencing of the lithologic facies in these metasedimentary rocks is interpreted to be the result of deformation before and during development of the Northern Gila Mountains Shear Zone.

Pzc — **Carbonate tectonite (Paleozoic protolith)** – Medium gray to pale gray to white, thinly layered to laminated marble and interleaved white and tan carbonate marble containing thin, fine sandy layers that make up as much as 10% of the white and tan carbonate. Small pendants consisting dominantly of marble are classified to this unit, but lithologically identical marble forms 40-50% of the Pzs unit as well, but the marble lenses are not differentiated.

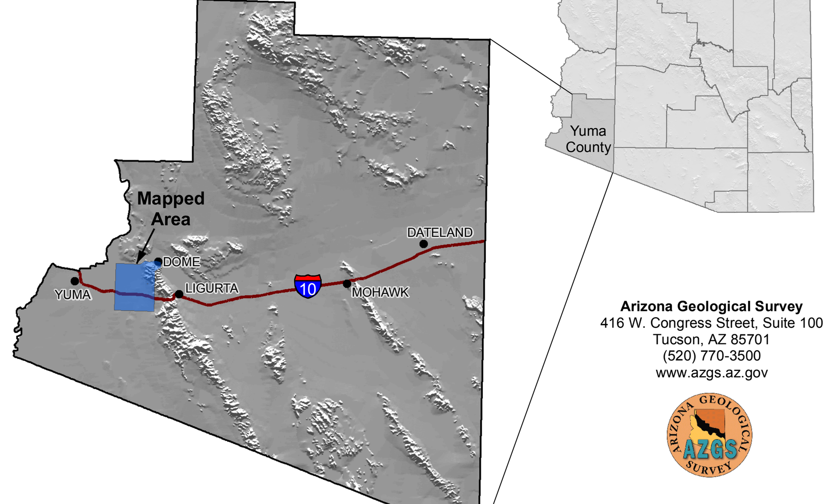
Pzq — **Quartzite tectonite (Paleozoic protolith)** – Tectonite derived from fairly pure, pale gray to pale tan quartzite with white coloration on parting surfaces. Rocks of this unit are possible correlative with the Permian Coconino Sandstone.

PPs — **Calc-silicate tectonite (Pennsylvanian and Permian protolith)** – Fine grained, tan to medium brown, quartzose metasandstone with thin layers of tan, recess-forming (by weathering), calcareous metasandstone. Sandstone also has laminations that form recesses or give outcrop relief on scale of mm that defines tectonite layering that looks like transposed bedding. Rock resembles metamorphosed and deformed Supai Formation in the Maria Fold and Thrust belt to the north.

Yg — **Megacrystic biotite granite of McPhaul Bridge (Mesoproteozoic)** – Dark biotite granite with K-feldspar megacrysts up to 5 cm diameter. Biotite is somewhat altered and fine grained, and forms felted aggregates up to 8 mm across. Mafics (mostly biotite) form 10-15% of rock, locally up to 20%. Olmsted et al. (1973, p. 32, written communication from L.T. Silver, 1968) report that similar granite near Yuma yielded a U-Pb zircon date of 1440 Ma. Named for outcrops in road cuts along approaches to McPhaul Bridge over Gila River between Gila and Laguna Mountains.

Xgn — **Granitic gneiss of Avenue 14 1/2 East** – Unit is a foliated to gneissic, heterogeneous mixed igneous complex--diorite-granodiorite-monzogranite-leucogranite; most granitic phases are light colored. Composition is relatively homogeneous on 10-100 m scale. Typical rock is medium grained equigranular granitic gneiss that contains 5-15% biotite; layering is quartz-feldspar-biotite ratio variations, grain size typically 2-5 mm, occasional 1-3 cm diameter augen are present. Assemblage ranges from fine-grained medium to dark gray biotite rich gneiss to light colored, weakly foliated granitoid layers, minor biotite pegmatite, some cross cutting granitoid dikes that are lithologically indistinguishable from weak to non-foliated granitoid layers. Accessory sphene(?) forms glassy honey-brown crystals. Metamorphic epidote is common, up to about 0.7 mm diameter. Rock is flooded in some areas with massive to very weakly foliated igneous phases; gneissic layering is not prominent in these zones. Darker colored phases tend to be more strongly foliated and appear older than lighter colored that are commonly less obviously foliated and form concordant to cross cutting dikes/blobs/lit par lit zones. High strain zones are characterized by grain size reduction (still with granoblastic texture), strongly developed layering, and straight foliation; these may have gradational or abrupt, concordant contacts to massive very weakly foliated granitoid. Blobs of dark gray, fine-grained, non foliated microdiorite and pods of ultramafic pegmatite are sparse. In northern exposures along the edge of the quadrangle, leucogranite is dominant phase, with coarse grained monzogranite, some pegmatite and lenses of medium gray quartz-feldspar-biotite gneiss. Leucogranite has about 2% 1 mm black opaque accessory mineral with red brown FeOx halos.

Location Index Map



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