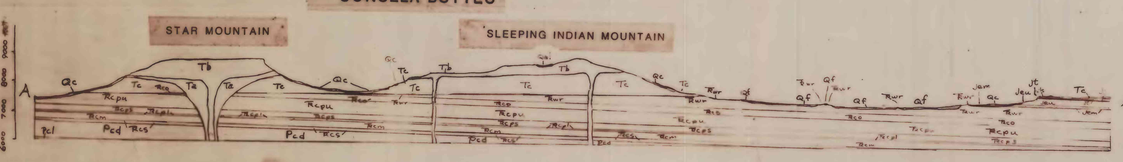
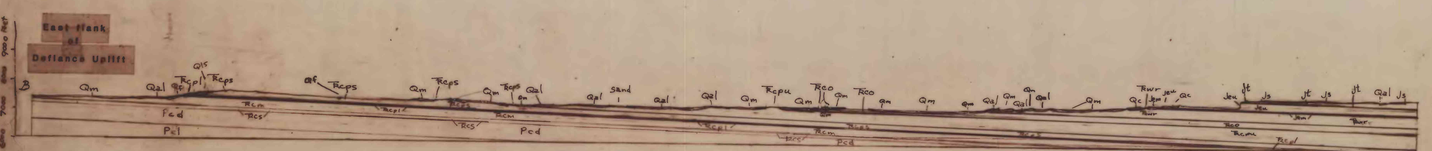
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN-FILE REPORT
80-788





CORRELATION OF MAP UNITS

Dune sand / Qal	Qf, Qs, Qls, Qlsg, Qlsv, Qtg, Qog	Qm, Qc	Holocene and Pleistocene(?) — QUATERNARY
Qoa	Qfo, Qos		
	UNCONFORMITY		
Tb, Ta, Tl			Middle Oligocene(?)
	UNCONFORMITY		
Tc	Td, Ttb, Tf, Tls		Lower Oligocene to Eocene(?) — TERTIARY
	UNCONFORMITY		
Jmr			Upper Jurassic
Jsu, Js*, Jcs, Jsl			
Jt			Middle Jurassic — JURASSIC
	UNCONFORMITY		
Jeu, Jem			
	UNCONFORMITY		
Trwr, Trco, Trcpu, Trcps, Trcpl, Trcm, Trcs*			Upper Triassic — TRIASSIC
	UNCONFORMITY		
Pcd, Pcl			Lower Permian — PERMIAN

DESCRIPTION OF MAP UNITS

[*Indicates letter symbol for a stratigraphic unit that is not exposed in quadrangle but is shown on cross sections]

SURFICIAL DEPOSITS (HOLOCENE AND PLEISTOCENE?)--Age range of individual units overlap; aggregates of superposed units may be as thick as 30 m

Qal ALLUVIUM--Clayey silt and fine sand, pale grayish orange to yellowish gray; locally includes dune sand; locally contains a few coarse sand grains or pebbles. Thickness commonly exceeds 3 m

Qoa OLD ALLUVIUM--Silty to gravelly alluvium, grayish orange to dark gray to reddish brown; lies topographically above younger sediment and valley floors

Qf FAN DEPOSITS AND SLOPE WASH--Torrential fan deposits, subangular to angular, poorly sorted, locally derived boulders and gravel; slope wash, deposited chiefly by gravity on slopes or at the foot of slopes. Thickness commonly exceeds 3 m

Qfo OLD FAN DEPOSITS--Semi-indurated gravel and boulder deposits in gray sand and silt matrix. Forms dissected elongate lobes

Qs SLOPE WASH DEPOSITS--Dark-gray to reddish-brown sand and silt deposited downslope from older and topographically higher slope wash (Qoa)

Qos OLDER SLOPE WASH DEPOSITS--Gravel, sand, and silt

Qls LANDSLIDE DEPOSITS--Includes undifferentiated toreva blocks. Landslides generally are older than the alluvium, and were formed during a wet period when large amounts of water percolated through porous sandstone (mostly the Sonsela Sandstone bed of the Petrified Forest Member of the Chinle Formation) and soaked and weakened the underlying shales (mostly the lower part of the Petrified Forest Member)

PIEDMONT ALLUVIAL BENCH GRAVEL DEPOSITS--Gravel, cobbles, and boulders; form bench-like structures; may be as much as 7.5 m thick

Qtgy Younger deposits

Qtgo Older deposits

Qtg Undivided

Qog PIEDMONT PEDIMENT GRAVEL DEPOSITS--Transported gravel, cobbles, and boulders, derived mainly from Chuska Sandstone of Chuska Mountains. Thickness may be as much as 1.8 m

Qm MANTLE DEPOSITS--Silt and sands derived mainly from underlying formation; mapped only in areas where significantly thick and extensive

Qc TALUS AND OTHER COLLUVIUM--Includes slide rock, soil mantle, and small areas of landslide (Qls), undifferentiated; poorly sorted, unconsolidated, locally derived rock fragments, large angular boulders, and soil. Thickness commonly 2 m

QTg GRAVEL DEPOSIT

VOLCANIC DEPOSITS (OLIGOCENE? TO EOCENE?)

Tb PORPHYRITIC TRACHYBASALT (MIDDLE OLIGOCENE?)--Trachybasalt, dark greenish gray, medium grained, light to bluish gray fine grained, olive green, medium grained, caps the highest points of East Sonsela Butte; gray, fine-grained trachybasalt caps West Sonsela Butte; comprises vesicular flow and other extrusive and instrusive basaltic rock bodies composed of biotite-phlogopite, clinopyroxene, in a groundmass of alkali feldspar, biotite, and accessory minerals; locally includes some glass

Ta TUFF BRECCIA (MIDDLE OLIGOCENE?)--Trachybasalt tuff, tuff-breccia, breccia, and subordinate trachybasalt agglomerate; locally includes small dikes and irregular bodies of minette and sparse to abundant large blocks and small fragments of sedimentary rocks

Ti MINETTE (MIDDLE OLIGOCENE?)--Intrusive basaltic rock, composed of biotite-phlogopite, minor clinopyroxene, alkali feldspar, and accessory minerals; forms volcanic neck in eliptical center of redeposited material (Tls)

Td DIKELIKE MASSES (TERTIARY)--Altered trachybasalt, medium light to dark gray, contains many vesicles and fractures filled with calcite or chalcedony possibly deposited from hydrothermal solutions

Ttb TUFF BRECCIA (TERTIARY)--Trachybasalt tuff breccia, dark gray to black; sparse to abundant small fragments to large blocks of igneous, metamorphic, and sedimentary rocks. Nearby minette dikes and plugs dated at 27.0 to 35.5 m.y. (Armstrong, 1969; Naeser, 1971)

Tf TRACHYBASALT FLOW (TERTIARY)--Local vesicular flow; intertongues with lower part of the Chuska Sandstone

Tls LANDSLIDE DEPOSIT (TERTIARY)--Sandstone, volcanic eruption probably disrupted Chuska Sandstone and allowed Chuska to slide into eliptical depression in underlying Jurassic Summerville Formation

SEDIMENTARY DEPOSITS

Tc CHUSKA SANDSTONE (LOWER OLIGOCENE TO EOCENE?)--Eolian sandstone, primarily pinkish gray (5Y 7/2) to yellowish gray (5Y 8/1), buff (5YR 5/6), and white; fine grained to medium grained; poorly bedded and massive crossbedded; grains have high sphericity and roundness and are mostly frosted. The beds range from 1.5 to 4.5 m thick, laminae range from 1 mm to about 17 cm thick. The angle of crossbedding ranges from 15 to 25 degrees and measurements of the strike indicate that the sands were blown from south-southwest. Certain beds or layers are firmly cemented with opal, chalcedony, and in some places, minor amounts of heulandite. A basal conglomerate of fluvial origin, 0.6 to 3 m thick, is composed of rounded pebbles (2.5 to 5 cm in diameter) of quartz, quartzite, sandstone, and slate, and less common subangular fragments of chert, limestone, and petrified wood. The basal conglomerate includes some interbedded siltstone, claystone galls, and in places, claystone lenses as much as 2 m in strike length and 0.4 m thick. The color of the claystone lenses is light red (5R 6/6), light brown (5YR 5/6), and dark yellowish-brown (10YR 4/6). The deposition of the basal conglomerate was by east-flowing streams. The basal beds are the Deza Formation of Wright, 1954. The top of the formation has been eroded at all places and covered by trachybasalt in most places. The Chuska overlies all older rock units with angular unconformity. Maximum thickness 232 m

x Bed (0.3 to 1 m thick) of manganese nodules

MORRISON FORMATION (UPPER JURASSIC)

Jmr Recapture Member--Quartzitic sandstone fine to medium grained; calcareous; pinkish gray to pale red; crossbedded; medium- to greenish-gray and reddish-brown claystone; conformably overlie the distinctly silty top beds of the Summerville Formation. Dominantly fluvial; eolian md lacustrine beds occur. Exposed only in extreme mid-eastern edge of quadrangle. Thickness 60-158 m

Js SUMMERVILLE FORMATION (MIDDLE JURASSIC)--Silty sandstone, moderate reddish orange (10R 6/6), pale reddish brown (10R 5/4), reddish brown (10R 5/6 to 10R 4/6), moderate brown (5YR 4/4), dark reddish brown (10R 3/4), and light brown (5YR 6/4 and 5YR 5/6); very fine grained to silt-sized; includes minor yellowish gray (5Y 8/1) structureless siltstone and thin dark-reddish-brown (10R 3/4) sandy and silty shale and mudstone. The sandstone is composed of well sorted, subrounded to subangular amber and colorless quartz grans. Alternating beds of massive sandstone as much as 9 m thick, and banded sandstone units as much as 14 m thick that have heavily iron-stained zones which are as much as 10 cm in thickness give an overall banded appearance. Deposition probably was mainly in shallow quiet-water ponds and on mudflats in a non-marine environment transitional between lacustrine and fluvial. In cross section Cow Springs Sandstone is mapped with upper and lower part of Summerville. Maximum thickness 63 m

Jsu Upper part--Overlies Cow Springs Sandstone

Jsl Lower part--Underlies Cow Springs Sandstone

Jcs COW SPRINGS SANDSTONE (MIDDLE JURASSIC)--Sandstone, light brownish gray (5YR 6/1), yellowish gray (5Y 8/1 to 5Y 7/2), pinkish gray (5YR 8/1), very light gray (N8), and white (N9); mostly very fine grained, but silt-sized locally, well sorted; consists nearly entirely of rounded quartz grains; flat-bedded and crossbedded in thick- to very thin beds. Deposition was in eolian and interdune environments. Maximum thickness 8 m

Jt TODILTO LIMESTONE (MIDDLE JURASSIC)--Limestone, light-bluish olive gray (5Y 6/1) to medium gray (N5), sandy and argillaceous, light brownish gray (5YR 6/1) to brownish gray (5YR 4/1); weathers pale brown (5YR 5/2); thick-bedded, interbedded with or grades into thin- to medium-bedded, light-bluish-gray limestone. Includes very thinly bedded calcareous sandstone lenses 3 mm thick in top 1 m ledge in southern and central parts of quadrangle. In some places in northern part of quadrangle, Todilto is thick-bedded calcareous sandstone. On top of limestone are mud cracks and ripple marks, also near top also is some platy sandy limestone, 0.6 m in thickness, wavy bedded. Flat chert and angular quartz pebbles, grayish orange pink (10R 8/2) and pale red (10R 6/2); range from 1-1/2 to 2 cm in width; occur along bedding planes. The Todilto has fetid odor on fresh breaks, forms a resistant ledge and also forms extensive dip slopes in eastern part of quadrangle; lower contact unconformable; deposited in lacustrine environment. Thickness generally 2 m but as much as 5 m at northeastern edge of quadrangle

ENTRADA SANDSTONE (MIDDLE JURASSIC)

Jeu Upper sandstone member--Sandstone, grayish pink (5R 8/2), grayish orange pink (10R 8/2 to 5YR 7/2), moderate reddish brown (10R 4/6), light brown (5YR 5/6), dark yellowish orange (10YR 6/6), and moderate reddish orange (10R 6/6; fine grained to medium grained, well sorted; composed mainly of subrounded to subangular quartz, frosted in part; locally contains scattered, coarse grains or granules along crossbeds. Grains generally are well-rounded, but finer grains tend to be angular. Crossbed laminae in some places, alternately fine grained and medium grained, or medium grained and coarse grained, with scattered granules; coarser grained near the base, finer grained toward top. Bleached, altered zone about 3 m thick immediately beneath the Todilto Limestone, grayish orange pink (10R 8/2) to very pale orange and white. Thicker zone of alteration under the bleached zone, chalk white, contains eroded sand grains coated with kaolinite(?) and isolated small clots of kaolinite(?). Bedding within the unit ranges from thin to very thick, corssbedding planar or trough type, ranging from high to low angle and small to large in scale. Forms prominent cliff. Top is an erosion surface. The contact with the underlying medial silty member is sharp and even. Environment of deposition mostly eolian dune sand and local temporary ponds. Upper sandstone member 14-56 m thick

Jem Medial silty member--Shaly mudstone and siltstone, moderate reddish orange (10R 6/6 to 10R 5/6), moderate yellowish brown (5YR 5/6), moderate redish brown (10R 4/6), and light brown (5YR 6/4); very thin to thick bedded; contains thin- to very thin-bedded interbedded fine-grained sandstone. Locally mottled light greenish gray. Bedding is even but inconspicuous on weathered surface due to member's well-cemented character. Sorting is good. Weathers blocky and knobby with distinctive ribbed appearance; forms vertical cliff. The lower contact is sharp. Deposition was in inland sabkha and interdune environments (Green and Pierson, 1977). Thickness 9-13.5 m

Trwr WINGATE SANDSTONE OF GLEN CANYON GROUP (UPPER TRIASSIC)

Rock Point Member--Sandstone, fine grained to very fine grained and siltstone, pale red (10R 6/2) to pale reddish brown (10R 5/4), moderate orange (10R 6/6), and moderate reddish brown (10R 4/6 to 10R 5/6) to dark reddish brown (10R 3/4). Sandstone, well sorted, firmly cemented, primarily of subrounded to subangular, colorless and amber quartz grains; friable, calcareous; trough crossbedded, most crossbedding is at low angles and of small to medium scale. Lower part (about 40 m) weathers to fairly uniform ledgy slope beneath vertical cliffs or spires of upper part. Forms series of four ledges of flaggy to rounded form. Siltstone, in even laminated beds, structureless in places, weathers flaggy and shaly. Most of bedding is very thin to thin (1-60 cm). Ripple marks, clay slicks, and worm trails and borings present. Fissile sandstone beds grade laterally into non-fissile beds. Environments of deposition were mostly eolian alternating with lacustrine. Maximum exposed thickness 153 m

CHINLE FORMATION (UPPER TRIASSIC)

Trco OWL ROCK MEMBER--Claystone, siltstone, and coarse pale-red and brown shale, interbedded with thin limestone, silty limestone, and chert-nodule limestone beds. Limestone, mottled very pale blue (5B 8/2) and grayish pink (5R 8/2); contains abundant chert nodules, mud pellets, lenses of lime-pellet conglomerate, and chert-limestone breccias; mostly of lacustrine origin; forms ledgy slopes. Siltstone, consists of moderate orange pink (10R 7/4), even and lenticular beds firmly to weakly bonded by calcareous cement. Calcareous nodules and impure limy zones common in siltstone. Depositional environment was lakes and streams. Thickness 40-56 m

PETRIFIED FOREST MEMBER:

Trcpu Upper part--Claystone, siltstone, mudstone, and minor amounts of sandstone and petrified wood, particularly in channels of former streams; even-bedded mudstone, siltstone, and sandy siltstone; variegated series of units; moderate grayish red (10R 4/4), pale reddish brown (10R 5/4), and pale reddish purple (5RP 6/2); forms badlands and rolling slopes; of fluvial origin. Thickness 63-160 m

Trcps Sonsela Sandstone Bed--Dominately tuffaceous sandstone, very fine grained to conglomeratic; light gray to yellowish brown and light brownish gray (5YR 6/1); lesser amounts of siltstone and shale, light gray (N7); several minor but similar sandstone beds, separated by layers of light bluish gray (5B 7/1) mudstone and siltstone. Sandstone is crossbedded and locally conglomeratic. Pebbles in conglomerate consist of chert, quartzite, and quartz. Pebbles, 0.4-5 cm in diameter, and clay clasts, 5-15 cm in diameter, aligned and show high to low energy stream transport. Crossbed measurements in sandstone indicate the Sonsela was deposited by streams flowing to the north (O'Sullivan, 1974). Crossbedded on medium scale and channels into underlying claystone and sandstone units as well as into lower part of Petrified Forest Member. Commonly contains carbonized and silicified wood. Many fossilized shells found in one locality, probably represent one species of pelecypod and belong to the family Unionidae. Unio cristonensis has been reported near Fort Defiance, Ariz. (Allen and Balk, 1954, p. 70). These fresh-water faunas usually characterized by abundance of individual specimens, but paucity of species probably indicate a river environment. Probable crocodile-like phytosaurian(?) tooth found in upper part of the Sonsela by Jay Scheevel. Forms ledges and benches. Unit thickens and thins from 113 to 60 m

Trcpl Lower part--Mudstone and lesser but varying amounts of tuffaceous siltstone and sandstone; pale blue (5B 6/2) to grayish blue (5PB 5/2), and grayish red purple (5RP 4/2); forms badlands and slopes. Depositional environment was fluvial in broad channels. Thickness 12-13.5 m

Trcm MONITOR BUTTE MEMBER--Mudstone, claystone, sandy siltstone, sandstone, and sandy conglomerate, mainly interatratified lenticular beds, thin to thick bedded. In the southwestern part of quadrangle member dominately very dusky red (10R 2/2) to grayish red (5GU 6/1), light-olive-gray (5YR 6/1), and light-greenish-gray mudstone-siltstone slopes interrupted by ledges of yellowish-gray (5Y 8/1) to light-brown (5YR 6/4) sandstone. Coarse-grained sandstone beds have silicious pebbles scattered in units or concentrated in small lenses. Most beds of silty, very fine- to fine-grained sandstone have climbing ripples. Conglomerate beds, brownish gray (5YR 4/1) or light olive gray (5Y 5/2); composed mainly of subrounded- to subangular limestone pebbles, minor amounts of petrified wood chips, and flattened mud pellets cemented in matrix of calcareous siltstone and sandstone. The sandstone of the Monitor Butte at Coyote Wash in western part of quadrangle is similar to the Shinarump Member but overrides upturned beds of greenish shale in the Monitor Butte Member. Throughout quadrangle, intraformational folding and upturned, distorted, and tilted beds common. Conglomeratic beds, or lag deposits associated with scour surfaces, occur throughout the Monitor Butte Member in chaotic orientations, in places cross-cutting upturned beds of Monitor Butte. Movement prior to consolidation, possibly the result of thrusting, probably caused the major distortions. Environment of deposition is fluvial. Thickness 60-91 m

Trcs* Shinarump Member--Sandstone, quartzose, very fine to very coarse grained, conglomeratic; tan, pale yellowish orange to yellowish gray, and light gray and grayish purple; lesser amounts of mudstone, pale red to light greenish gray; fluvial origin; high energy sandstones, crossbedded; locally contain concentrations of silicified and carbonized wood; forms cliffs or ledges. Basal contact is an erosion surface. The Shinarump generally channels or scours into the underlying De Chelly Sandstone Member. Thickness 0-30 m

CUTLER FORMATION (LOWER PERMIAN)

Pcd De Chelly Sandstone Member--Sandstone, grayish orange pink to moderate reddish orange; fine to medium grained, crossbedded; of eolian sand dune origin. Thickness 76 to 137 m

Pcl Lower part--Sandstone and siltstone, moderate reddish brown to moderate reddish orange; fine grained, thin to thick bedded; some crossbedding of mostly flood-plain origin. Thickness about 220 m

EXPLANATION OF MAP SYMBOLS

- CONTACT
- FAULT--Dotted where concealed; queried on section. Where sense of displacement is known, bar and ball on downthrown side
- STRIKE AND DIP OF BEDS
- ANTICLINE--Showing surface position of crestline. Arrow indicates plunge
- SYNCLINE--Showing surface position of troughline. Arrow indicates plunge
- HORIZONTAL BEDS
- EARTH DAM

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GEOLOGIC MAP AND SECTIONS OF THE SONSELA BUTTE 4 SE QUADRANGLE, APACHE COUNTY, ARIZONA, AND SAN JUAN AND MCKINLEY COUNTIES, NEW MEXICO

By
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1980