A SUMMARY OF THE DEPOSITIONAL ELEMENTS AND SETTING OF THE LATE CENOZOIC GILA GROUP, CENTRAL DUNCAN BASIN, SOUTHEAST ARIZONA

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Abstract

This study documents the sedimentation and depositional history of the upper Pliocene to lower Pleistocene Upper Gila Group basin fill in the central Duncan basin, Greenlee County, southeast Arizona. The north-northwest trending intermontane Duncan basin is uniquely situated near the junction of the southern Basin and Range, Transition Zone, Colorado Plateau, and Rio Grande rift physiographic provinces, all of which had some influence on the structural evolution of the slightly asymmetric basin.

Between the towns of Duncan and Three Way, Arizona, forty-one stratigraphic sections, mostly of the Upper Gila Group, were measured and described to determine a facies classification of the basin-fill deposits. Seven depositional facies were recognized. Their lateral and vertical distribution within measured sections and mapped areas were the basis for defining six significant depositional elements used to reconstruct the Plio-Pleistocene depositional history and paleogeography of the central Duncan basin. The six depositional elements include: *streamflood-dominated alluvial fans, distal sheetflood alluvial fan, axial braided fluvial, floodbasin, lacustrine, and high basin stand deposits.*

The streamflood-dominated alluvial fans are prominent along the southwest margin of the central Duncan basin, and are characterized by four distinct fan associations that were all locally sourced from the Peloncillo Mountains to the west. These fans generally prograded east and onlapped and interfingered with an areally extensive floodbasin that occupied much of the central Duncan basin. This floodbasin acted as a catchment area for the fine-grained sediments sourced from the alluvial fans systems along the basin margins. Parts of the floodbasin near Duncan were occupied intermittently by extensive freshwater lakes with benthic conditions that supported diatom growth. A prominent distal sheetflood alluvial fan occupied the northern part of the field area. It represents the distal portion of a large southeast prograding axial alluvial-fan system sourced from the elevated Morenci block at the head of the basin. An axial braided fluvial system also was sourced from the Morenci block and flowed southeast along the southwest

margin of the basin and dispersed into the floodbasin.

Deposition of the Gila Group basin fill terminated with the deposition of dominantly alluvial-fan deposits locally sourced from the northeastern basin margin. These gravel deposits cap high mountain-front mesas in the Duncan basin and are similar to terminal basin-fill deposits in other basins that are known regionally as the high basin stand (HBS). They were deposited just prior to and/or during entrenchment by the modern Gila River between 2.0 - 1.0 Ma, and are a coarse-grained response to a climatic and/or a tectonic shift during the latest Pliocene and early Pleistocene.

A Blancan-aged horse molar, *Equus simplicidens*, found in the Upper Gila Group, permits stratigraphic correlation to other nearby studies, and suggests that the Gila Group deposits in the central Duncan basin are primarily late Pliocene to early Pleistocene (3.7 - 1.0 Ma).

INTRODUCTION

Southeast Arizona and southwest New Mexico are regionally dominated by a series of en-echelon NW-trending structural basins (i.e., the Safford basin, the Bonita Creek basin, the Duncan basin, and the Mangas valley) (see fig. 1). These basins are predominantly filled with Miocene and younger Gila Group deposits, studied originally by Gilbert (1875), and are situated in a transitional physiographic setting between the Colorado Plateau and the Basin and Range (fig. 1). One of these basins, the Duncan basin, has not been extensively studied, and its relationship to neighboring basins is not well understood.

Fault-bounded uplifted structural blocks, common physiographic features of both the Transition Zone and southern Basin and Range, promote basin fill sedimentation in adjoining basins (Enders, 2000). These intermontane syntectonic erosional windows of basin fill provide valuable clues to understanding the Cenozoic evolution of the southwest United States. Basin fill sedimentation in these settings generally consists of depositional elements that interfinger and onlap in directions both transverse to (e.g., basin margin alluvial fan packages), and parallel to the basin axis (e.g., axial fluvial systems), as well as slope-independent depositional elements

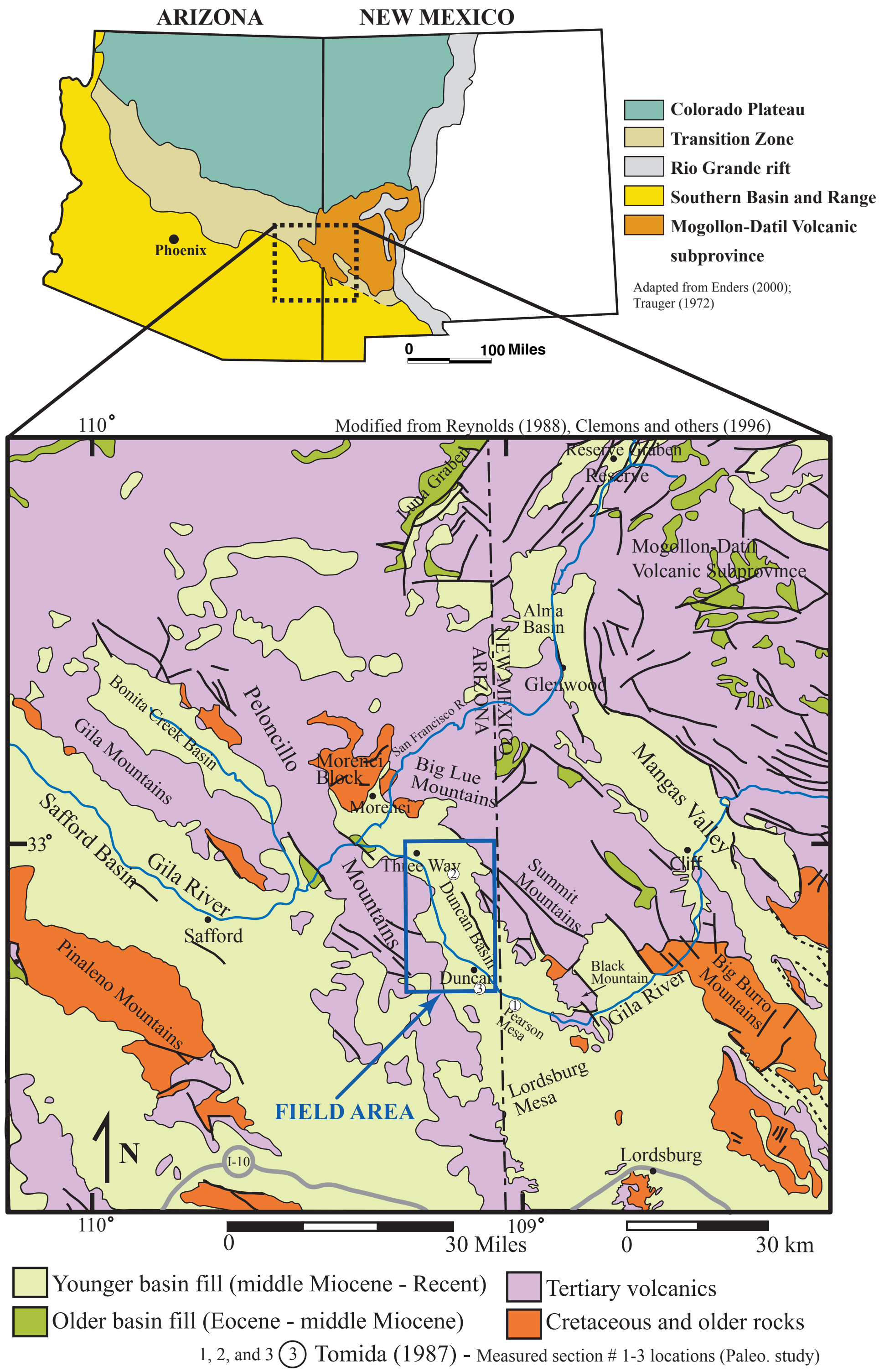

Figure 1. A, Map showing the major physiographic provinces of western New Mexico and Arizona. The Duncan Basin lies within the northeast margin of the Mexican Highland Subprovince of the southern Basin and Range Province. B, Simplified geologic map of southeast Arizona and southwest New Mexico. Normal faults are shown as black lines (dashed whre inferred).

such as lakes, floodbasins, swamps, playas and ergs (Leeder and Gawthorpe, 1987; Crews, 1990 and 1994; Smith, 1999; Gawthorpe and Leeder, 2000). Excellent exposures of these types of depositional elements occur in the Duncan basin. Specifically, the upper section (Pliocene–lower Pleistocene) of the

Gila Group basin-fill deposits have been incised since the early Pleistocene by the modern Gila River and its tributaries, permitting field evaluation of the depositional history of the central Duncan basin.

Previous studies of the Gila Group in the field area have classified the sediments into several informal subgroups, formations or sequences; however, these studies have not adequately addressed the depositional facies and depositional setting of the Duncan basin. Therefore, the objective of this paper is to document the sedimentation patterns and depositional history of the exposed Upper Gila Group in the central Duncan basin. Accordingly, a thorough analysis of the Gila Group depositional facies, depositional elements, and relative timing of deposition is necessary in order to better understand the Upper Gila Group basin fill and properly construct a depositional model for the basin.

Acknowledgements

Edward Theriot (Univ. of Texas at Austin Dept. of Biological Sciences) provided insight on the lacustrine diatoms, Kate Herrell reviewed the manuscript, Steve Enders, and William Galloway provided valuable opinions.

PREVIOUS WORK

The studies that focus, in part, on the Gila Group either in or near the Duncan basin include the following: Morrison (1965), Richter and others (1983, 1990), Drewes and others (1985), Hedlund (1990, 1993), Smith (1999), Enders (2000), and Ferguson and Enders (2000). All of these studies include geologic maps at different scales that include the Gila Group as one of the mappable formations.

The study by Richter and others (1983) to the west of the Duncan basin extended the original definition of the Gila Conglomerate of Gilbert (1875) and Knechtel (1938) by sub-dividing it into five mappable units based primarily on textural and bedding characteristics. However, only three of these units crop out in the Duncan basin: conglomerate of Midnight Canyon (Pliocene and/or Miocene), fluviatile deposits of Buzzard Roost (Pliocene), and the alluvium of Smuggler Canyon (Pleistocene and Pliocene). This stratigraphic framework was later modified by Ferguson and Enders (2000), who sub-divided the Gila Group into seven informal units based on clast content, and to a minor extent, lithification and sedimentology.

Heindl (1962, 1963), Morrison (1965), Trauger (1972), Leopoldt (1981), and Richter and others (1988) divide the Gila Group into two informal stratigraphic units in the Duncan basin, an indurated "lower zone" (20 – 10 Ma) and a moderately consolidated "upper zone" (10 – 1.5 Ma), separated by an angular unconformity. Drewes and others (1985) divide the Gila Group into coarse-, medium-, and fine-grained sequences.

Smith (1999) studied the Cenozoic depositional history of the Gila Conglomerate of the Duncan and Canador Peak Quadrangles to the SW of the field area in New Mexico. Smith (1999) sub-divided the Gila Conglomerate into three mappable members: the Wilson Mine and Nichols Canyon members (equivalent to the lower zone of the Gila Group), and the Pearson Mesa Member (equivalent to the upper zone of the Gila Group).

Tomida (1987) and Morgan and Lucas (2000) classified Blancan (4.5 – 1.9 Ma) vertebrate faunas and measured stratigraphic sections in the Upper Gila Group in the Duncan basin. Additionally, Tomida (1987) determined the paleomagnetic stratigraphy and age of the Upper Gila Group in the Duncan and Safford basins in order to correlate it to the vertebrate faunas.

DUNCAN BASIN GEOLOGY AND STRUCTURE

Figure 1 shows that the Duncan basin is a NNW trending basin that straddles the Arizona – New Mexico border. It is approximately 60 km in length and varies in width from 8 - 14 km. The total basin area is 700 km^2. The northwest boundary of the basin is a NE-SW bounding normal fault located approximately 1.5 km upstream of the confluence of the Gila and San Francisco Rivers (Enders, 2000). This fault separates the Duncan basin from the Morenci block that lies to the northwest of the Duncan basin (fig. 1). The SE termination of the basin is the Quaternary Lordsburg Mesa in New Mexico. The field area is situated entirely in Greenlee County, Arizona, and is 16 km wide and 30 km long, extending from just north of the highway intersection known as Three Way, to just south of the town of Duncan, Arizona (figs. 1 and 2).

The Big Lue, Summit, and the Peloncillo Mountains rim the basin (fig. 1) and are dominated by mid-Tertiary volcanics that range in age from 34 – 18 Ma (Morrison, 1965; Wahl, 1980; Richter and Lawrence, 1981; Richter and others, 1983; Drewes and others, 1985; Ratté and Brooks, 1995), and include volcanic Sequences 1, 2, 3, 4, and 6 of Ferguson and Enders (2000). These mid-Tertiary volcanic rocks are mostly sequences of andesites and basaltic andesites (80-90%), and minor amounts of rhyolitic to dacitic flows, tuffs, and breccias (10-20%) (Witcher, 1981; Enders, 2000). These assemblages are intercalated sequences derived from the Mogollon-Datil volcanic subprovince, and the Peloncillo volcanic fields of the southern Basin and Range (Enders, 2000). The Morenci block (fig. 1) is a fault-bounded block comprised of a triangular window of Precambrian igneous through early Tertiary volcanic rocks (Enders, 2000).

Fault exposures and gravity data suggest that the geometry of the Duncan basin is characterized by a slightly asymmetric structural graben with the basin-bounding step-like NW-striking, SW-dipping normal faults located along the northeastern margin of the basin (Drewes and others, 1985; West, 1996; Enders, 2000). The bounding faults are steeply dipping at 75^{o} to 85^{o} toward the basin (SW), and are continuously exposed for about 24 km along the northeastern margin of the basin (Enders, 2000).

The depths to bedrock in the Duncan basin range from 1,830 m south of the Morenci block to 762 m near Duncan (West, 1996). These deep basin depths imply that the basin has had both an active and prolonged basin filling history. Basin subsidence and consequent filling of the Duncan basin began during the later stages of volcanism and during the initial stages of Basin and Range extensional tectonics (i.e., around 18 Ma) (Richter and others, 1983; Ferguson and Enders, 2000).

Modified from Drewes and others (1985)

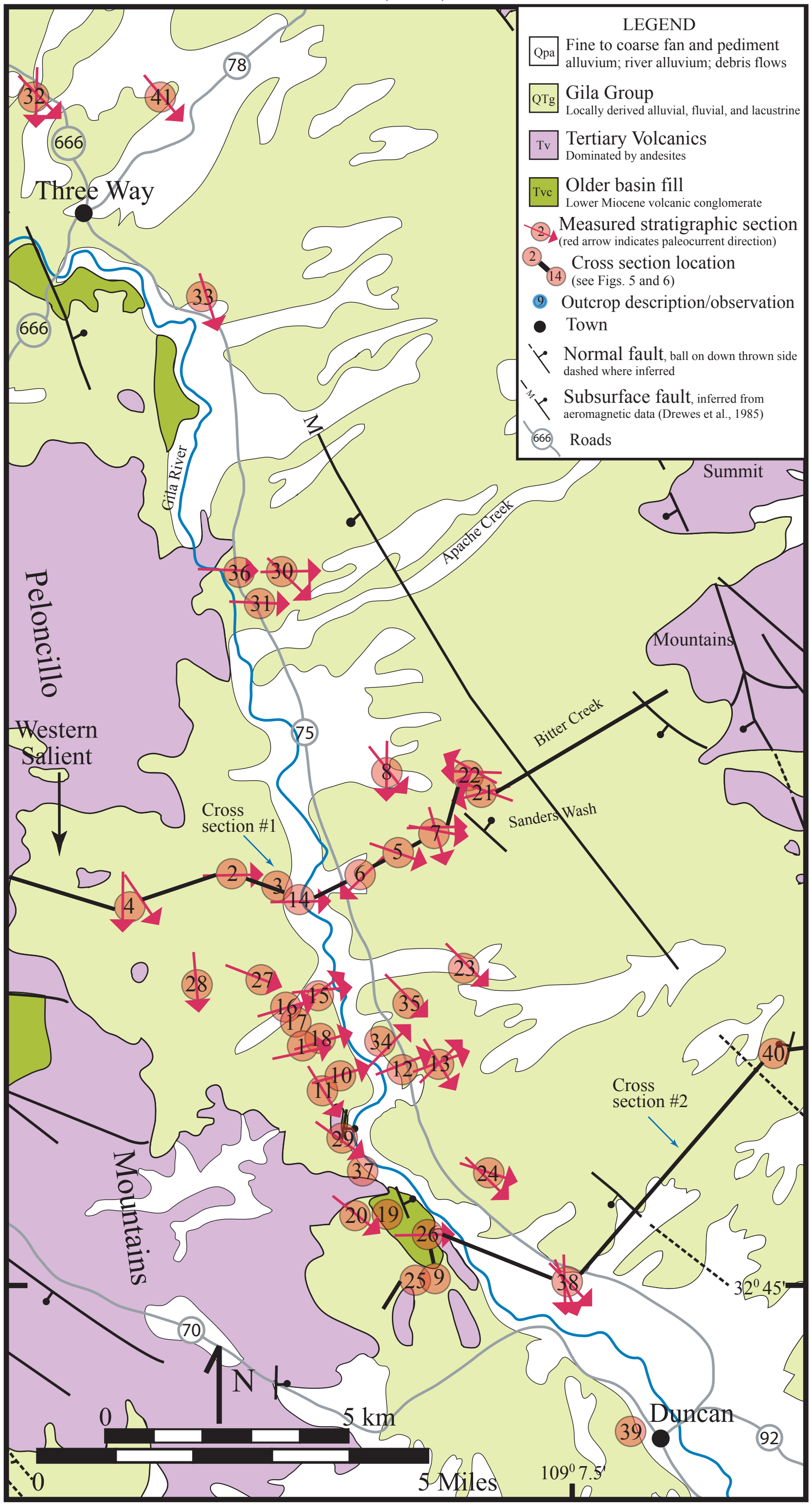

Figure 2. Field map showing locations of measured sections S1-S41 with paleocurrent data and the locations of cross sections #1 and #2.

FIELD AREA

A few physiographic features are worth noting in the field area. The "Western Salient" is an embayment 13 km NW of the town of Duncan along the southwest margin of the basin (fig. 2) that is filled with primarily coarse-grained Gila Group deposits. These deposits comprise several fan associations distinguished by differences in color, texture, and lithology. Additionally, along the southern and eastern parts of the Western Salient are several small irregularly shaped volcanic-bedrock highs that are separated from the main volcanic highlands that denote the southwestern basin boundary. For example, a prominent volcanic-bedrock high (shown in fig. 8) forms a knob just to the north of S29 (fig. 2), and is composed of white, thinly layered (5 – 50 cm) pumice-rich ash flow tuffs, as well as distinct layers of basalt and andesite. There are also bedrock highs near S4, S9, S25, S26, and S28 (fig. 2). The volcanic-bedrock highs near S9 and S25 have bedding planes that dip NE and may represent isolated Basin and Range tilt blocks.

In the field area, only a few measured sections contain Gila Group deposits equivalent to the lower zone of the Gila Group which is equivalent to the conglomerate of Midnight Canyon of Richter and others (1983) and Ferguson and Enders (2000)). Most of the measured sections contain Gila Group deposits equivalent to the upper zone which is also equivalent to the units of Buzzard Roost and Smugglers Canyon of Richter and others (1983) and Ferguson and Enders (2000)). Consequently, most of the exposures and measured sections of the Gila Group in this study shed insight on the later stages of basin evolution.

DEPOSITIONAL FACIES CLASSIFICATION

Depositional facies determination in terrestrial basins is essential in order to understand basin formation and evolution. Facies identification has several implications including knowledge of depositional process and environment, whether depositional elements are prograding, aggrading, or retrograding, amount of relative subsidence, energy of transport, as well as implications on paleoclimate and tectonics (Crews, 1994; Leeder and Gawthorpe, 1987).

Thus, determination of a facies classification of the Gila Group in the Duncan basin is essential in order to properly interpret the depositional history.

Lithology, degree of lithification, grain size, sedimentary structures, vertical and lateral relations, paleocurrent, and clast lithologies were integrated to formally recognize and interpret seven unique depositional facies in the Duncan basin: *clast-supported debris flow conglomerate (Facies 1), matrix-supported debris flow conglomerate (Facies 2), clast- and matrix-supported streamflood conglomerate (Facies 3), sheetflood sandstone and conglomerate (Facies 4), axial fluvial sandstone and conglomerate (Facies 5), lacustrine diatomaceous sediments (Facies 6), and floodbasin mudstone and sandstone (Facies 7)*. In addition, the modern Gila River terrace and alluvium deposits were informally recognized and included in measured sections for this study. Facies determination was based on interpretation of forty-one measured stratigraphic sections and sixteen outcrop descriptions made of primarily the Upper Gila Group in the central Duncan basin. Figure 2 shows the locations of the measured sections, outcrop descriptions, and where measurements were made, paleocurrent indicators. Paleocurrent directions were determined from clast imbrications, trough and planar cross-stratification, and overall channel trend geometry, and yielded two dominant trends: (1) flow parallel to the basin axis, and (2) flow transverse to the basin axis (fig. 2).

Table 1 summarizes the essential observations and interpretations of each of the seven formally recognized facies, and Figure 3 shows a representative photograph of each of the seven facies recognized. Figure 4 is a map that demonstrates the lateral facies distribution of the seven depositional facies within measured sections in the Duncan basin. Each pie chart represents one measured section and the corresponding relative facies percentage for each measured section.

Two west-to-east cross sections (figs. 5 and 6) were constructed using measured stratigraphic sections to help illustrate the vertical and lateral facies relationships that occur in the Duncan basin. Both cross sections show primarily braided axial fluvial, lacustrine, and floodbasin facies (Facies 5, 6, and 7) on the eastern parts of the cross sections, while clast- and matrix-supported debris flows and streamflood conglomerates (Facies 1 – 3) dominate the

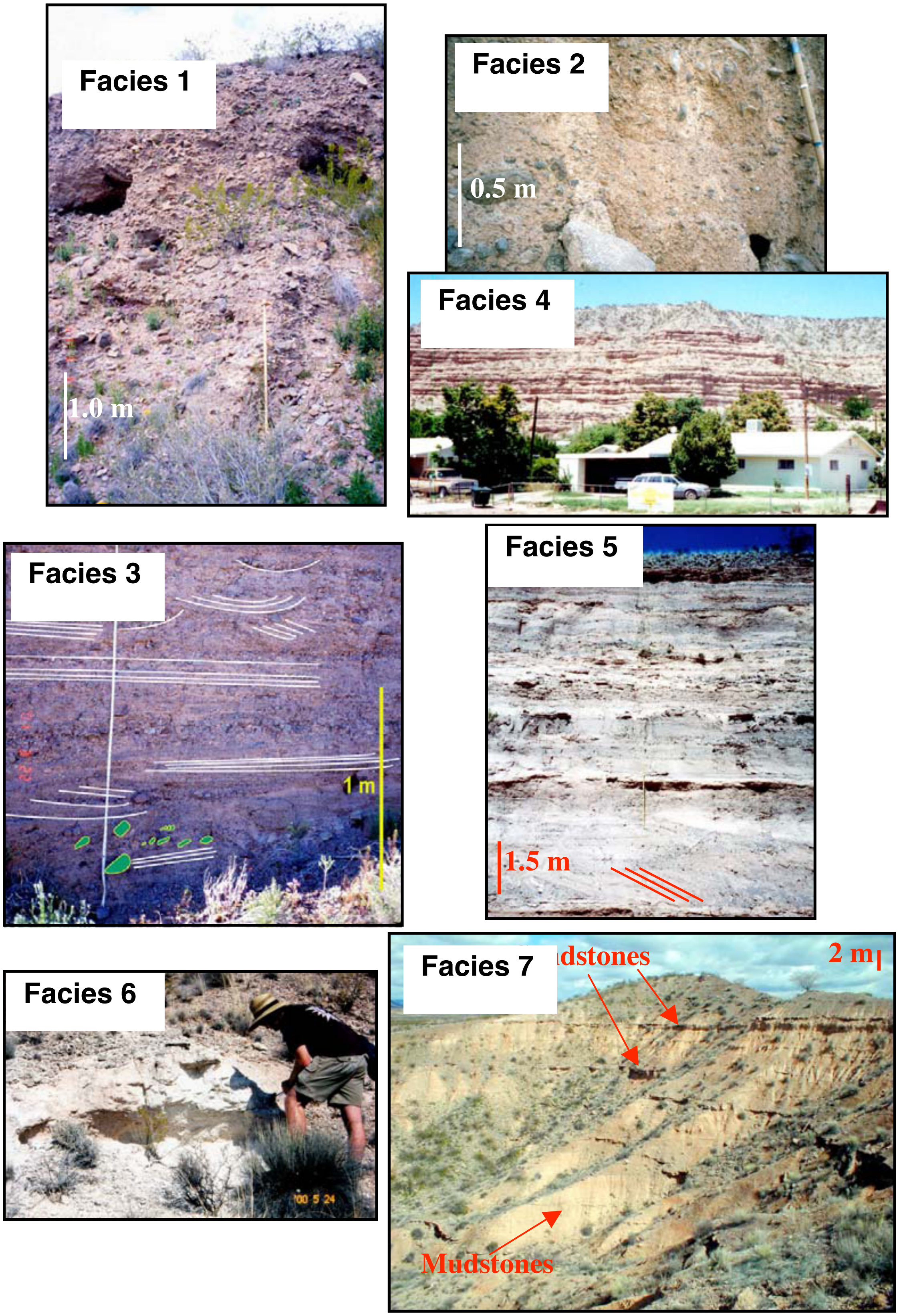

Figure 3. Photographs showing examples of Duncan Basin depositional facies 1-7 in exposures.

	Observations		Interpretation	
Facies	**Sedimentary Structures**	**Lithofacies Description**	**Depositional Process**	**Depositional Environment**
1. Clast-supported debris flow conglomerate	Rare reverse grading, rare weak clast imbrication.	Red to brown laterally discontinuous granule to boulder clast-supported conglomerates. Very poorly sorted and stratified.	Sediment gravity flows. Coarse-grained gravity driven deposits.	Proximal alluvial fan.
2. Matrix-supported debris flow conglomerate	Rare reverse grading, rare weak clast imbrication.	Red to brown laterally discontinuous granule to boulder matrix-supported conglomerates. Very poorly sorted and stratified.	Sediment gravity flows. Coarse-grained gravity driven deposits.	Proximal to medial alluvial fan.
3. Clast- and matrix-supported streamflood conglomerate	Trough cross-stratification, horizontal stratification, channels, weak to moderate imbrication, reverse and normal grading.	Red to brown moderately continuous granule to boulder matrix- to clast-supported conglomerates. Poorly sorted, moderately stratified.	Shallow channelized fluid-gravity flows.	Proximal to distal alluvial fan.
4. Sheetflood sandstone and conglomerate	Horizontal stratification, trough and planar cross-stratification, planar orientation of clasts, imbrication, normal grading, localized scours, high width:depth channels, stringers.	Tan to light brown medium- to thick-bedded (20 cm – 1.5 m) tabular sandstone and conglomerate with extremely high width to depth bedding planes. Lateral continuity of the beds commonly exceeds 50 - 100 m.	Shallow, unconfined fluid-gravity flows. Upper flow regime.	Distal alluvial fan to alluvial flat.
5. Axial fluvial sandstone and conglomerate	Large-scale trough and planar cross-stratification, imbrication, normal grading, planar stratification, channels, stringers.	Tan to grey medium to granular sandstones and matrix- and clast-supported well to subrounded pebble to boulder conglomerates. Well sorted, well defined bedding planes.	Shallow channelized flow.	Axial braided fluvial.
6. Lacustrine diatomaceous sediments	No primary sedimentary structures.	White, light, loosely consolidated medium bedded diatomites. Grey to green silicic nodules, fossils. Beds often continuous >100 m.	Shallow water suspension fallout sedimentation.	Lacustrine, basin axis, interior basin.
7. Floodbasin mudstone and sandstone	Rare trough and planar cross-stratification, horizontal stratification, imbrication, normal graded beds. Localized scours, channels, and gravel stringers.	Mostly massive, loosely consolidated red to tan mudstones with laterally continuous very fine to coarse tan to brown channel and sheet sandstones.	Overbank flow, dominantly suspension fallout sedimentation. Massive flood deposits in a closed basin.	Flat interior basin.

Table 1. Summary of observations and interpretations of the central Duncan basin depositional Facies 1-7.

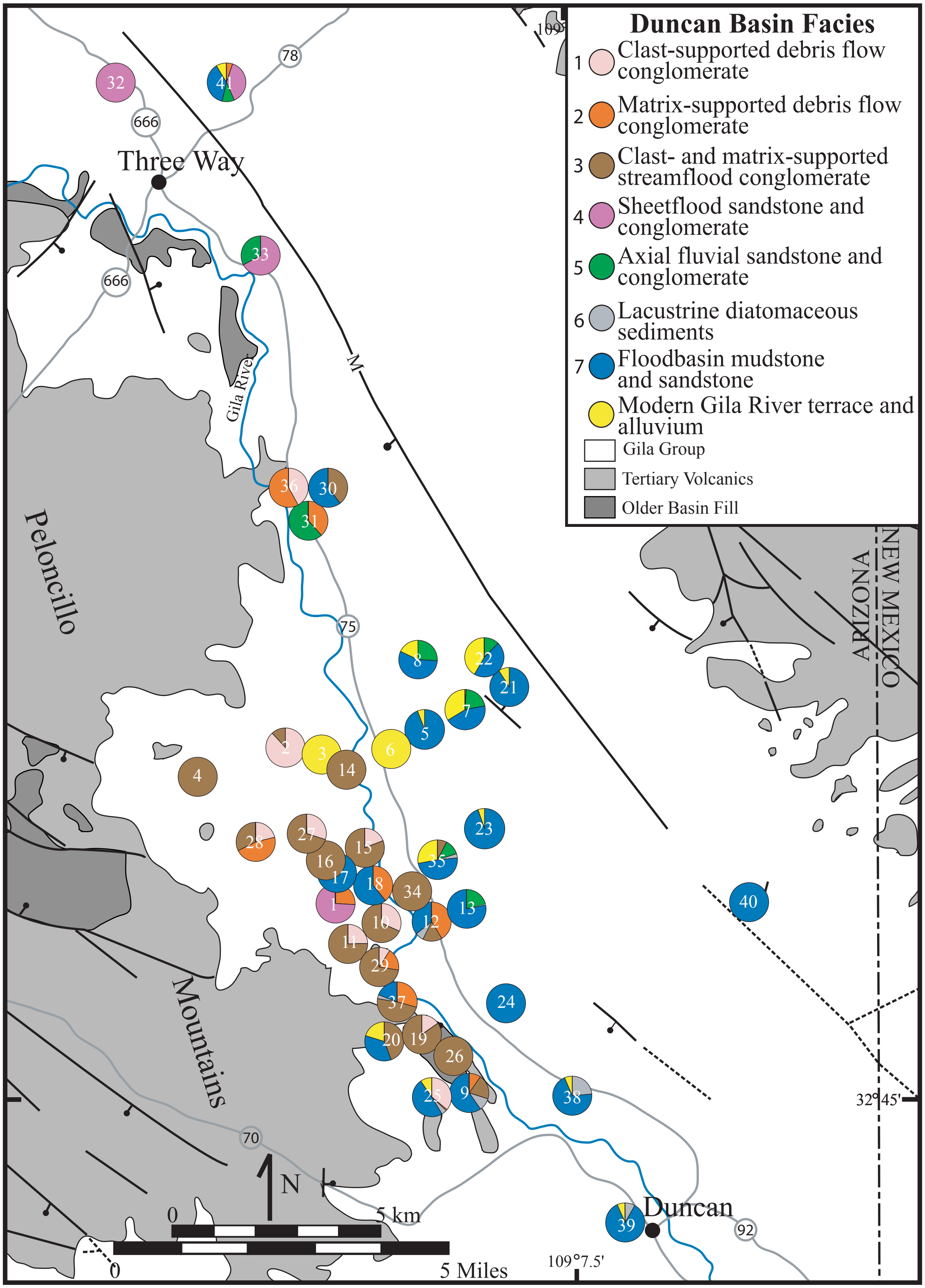

Figure 4. Map showing relative measured section distribution for all depositional facies. Note the rapid facies changes perpendicular to the basin axis, which are typical of the Gila Group.

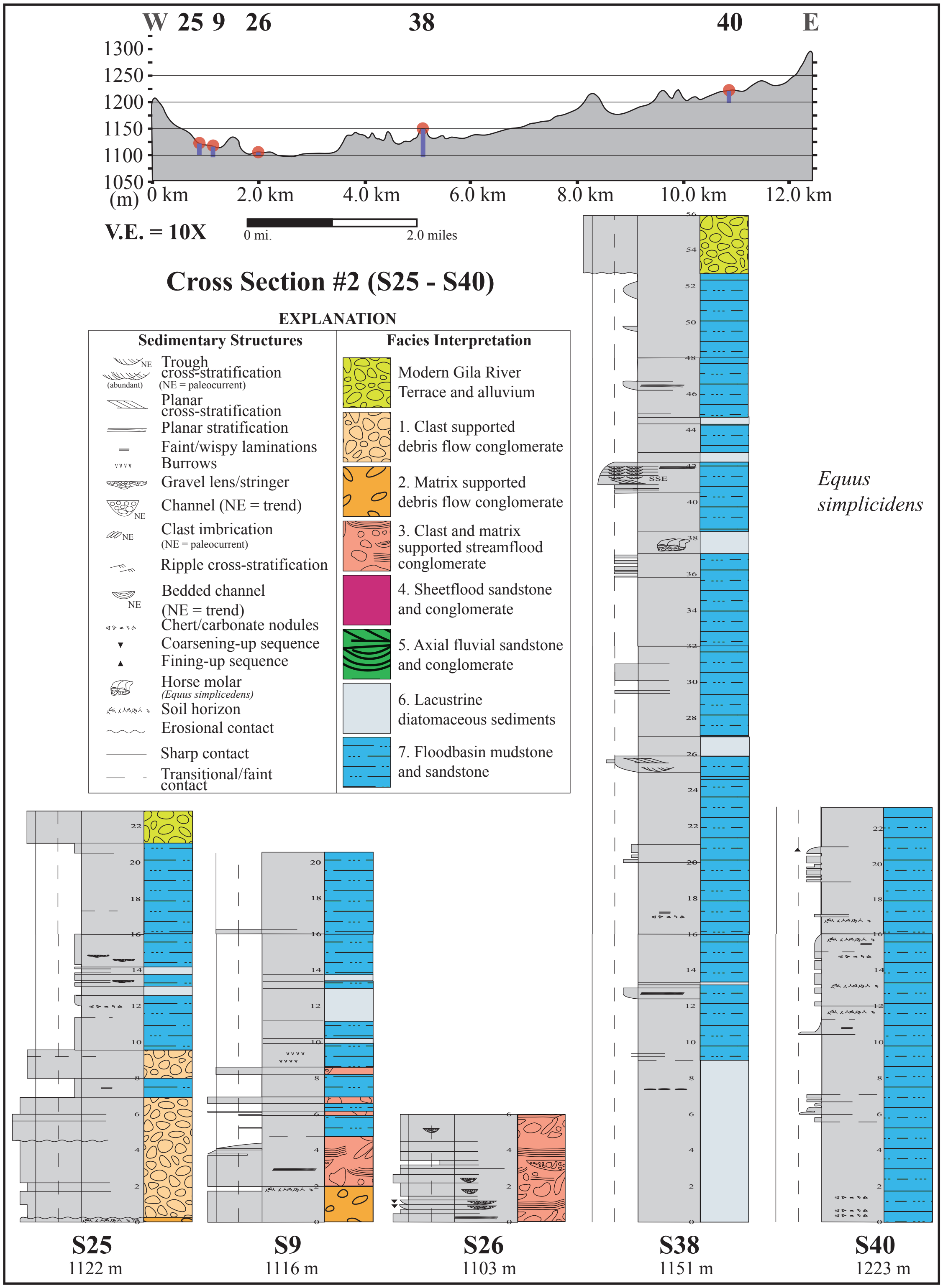

Figure 5. West-to-east cross section #1 from measured section S4 to S21. Elevations under measured section label refer to top of measured section. Blue bars on topographic profile represent measured section thickness.

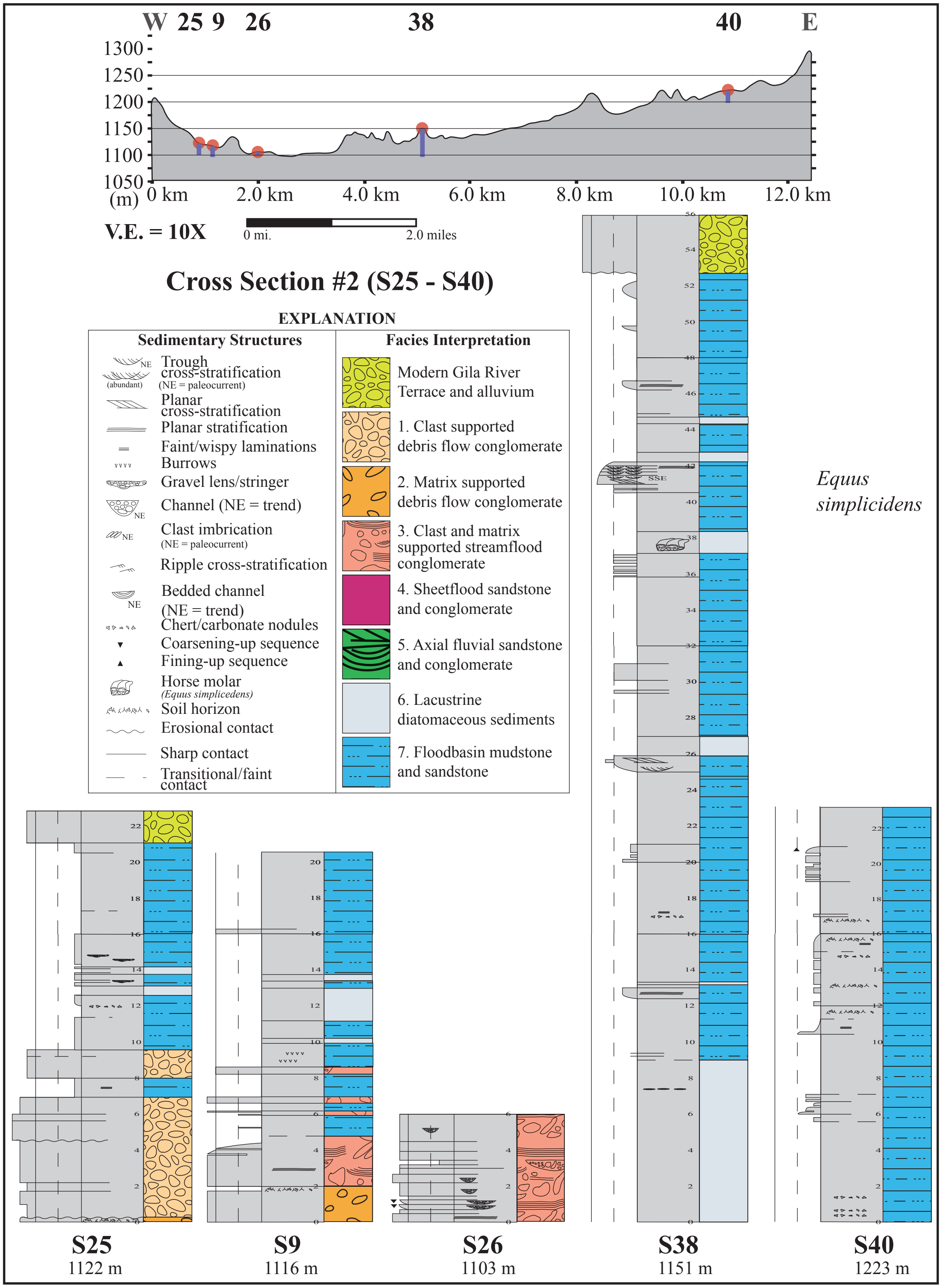

Figure 6. West-to-east cross section #2 from measured section S25 to S40. Elevations under measured section label refer to top of measured section. Blue bars on topographic profile represent measured section thickness.

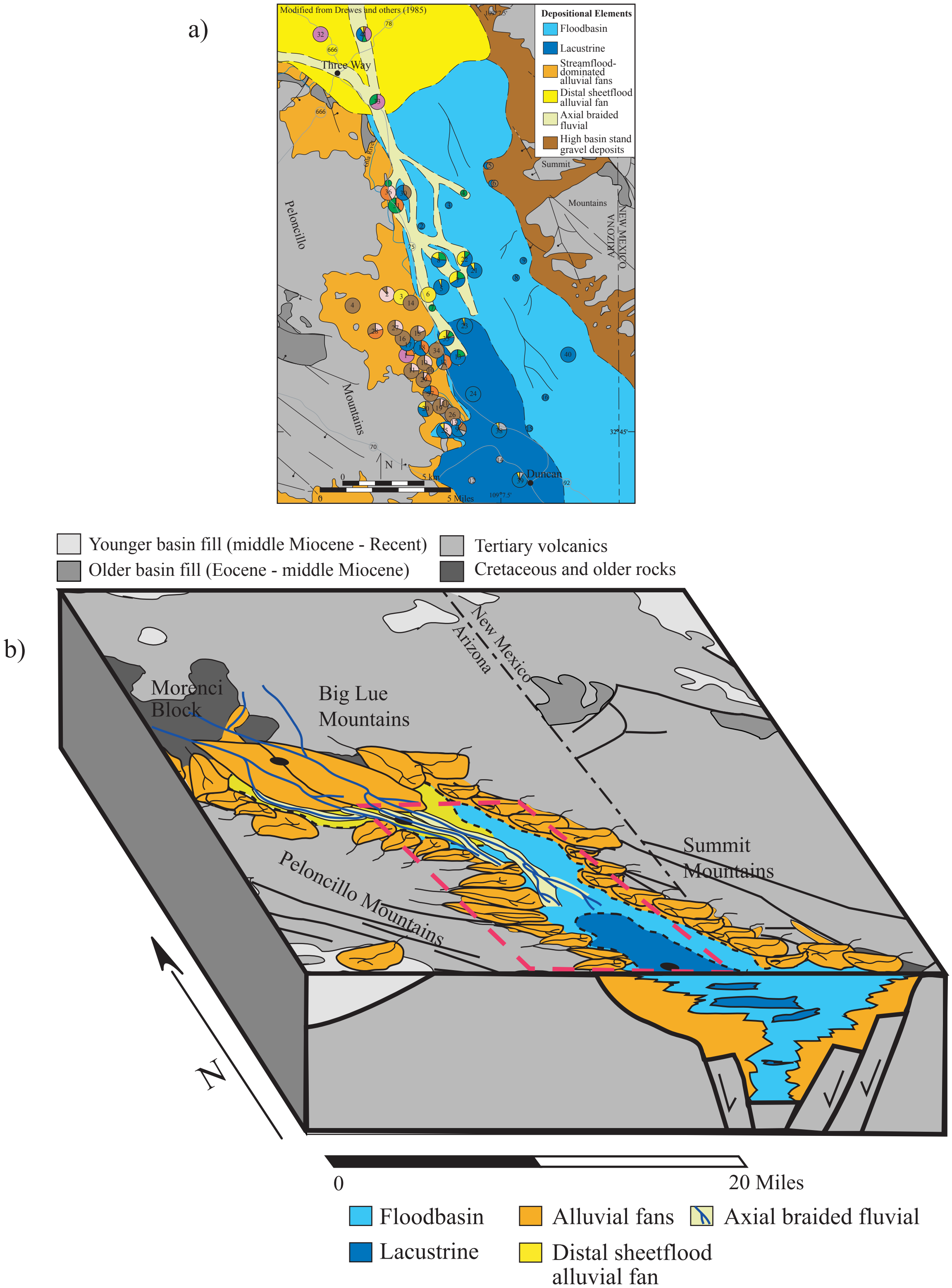

Figure 7. A, Composite schematic diagram showing depositional elements interpreted from the facies classification. B, Pliocene-Pleistocene depositional moded of the Duncan Basin. The field area is outlined in red. The thick black lines denote normal faults. Geologic base map from Drewes and others (1985).

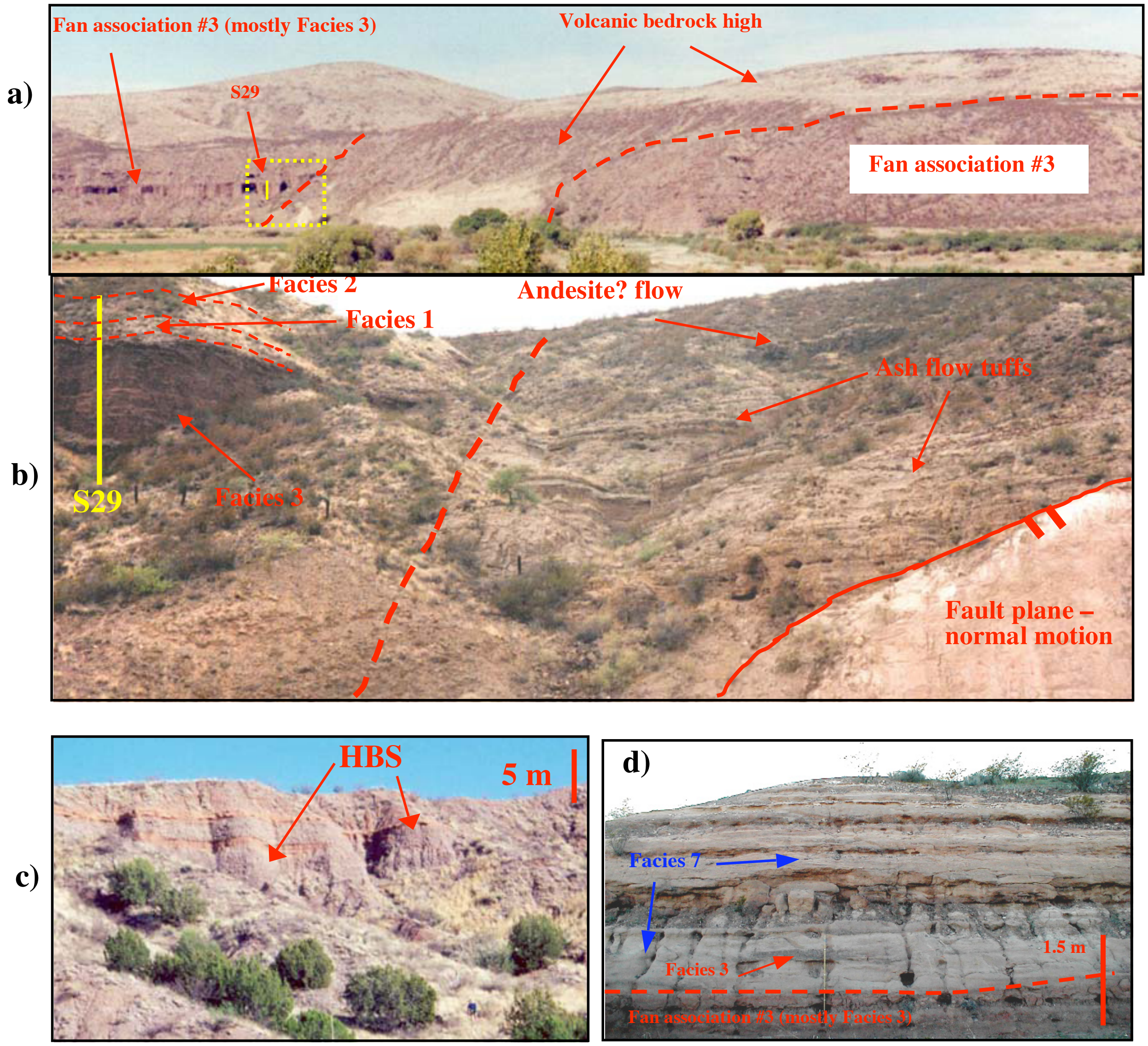

Figure 8. A, Photograph of outcrop showing a bedrock high near S29 (view is looking southwest). Fan association #3 wraps around the bedrock high. The red dashed lines mark the contact between the bedrock high and the Gila Group. B, Close-up photograph of the area in the yellow dashed square depicted in A. The red dotted line represents the contact between the bedrock high and primarily Facies 3 of the Gila Group. The yellow solid line denotes location of S29 (12 m). The red solid line traces steeply dipping fault gouge (37˚ to 75˚) from normal fault where the up-thrown block is the bedrock high. C, Photograph of gravel deposits (shown by red arrows) along the northeastern margin of the Duncan Basin that represent the high basin stand (HBS) deposit near the Pliocene-Pleistocene boundary. D, Photograph of outcrop depicting the interfingering of fan association #3 (shown by red arrow) with Facies 7 (shown by blue arrows) in S12.

western parts of the cross sections. The modern Gila River is more or less the dividing line between this contrasting textural character of the cross sections.

The cross sections also demonstrate that the floodbasin deposits are at the same stratigraphic level and in some cases, higher than the coarse-grained vertical equivalents that crop out along the southwestern margin of the basin (Facies 1 –3) (figs. 5 and 6). It is likely that the floodbasin facies and the clast- and matrix-supported debris flows, and streamflood conglomerates (Facies 1 – 3) were deposited contemporaneously and interfingered. Evidence for the interfingering of these facies is demonstrated in S9 of figure 6 (cross section #2), which shows alluvial fans (Facies 2 and 3) interfingering with floodbasin (Facies 7), and lacustrine (Facies 6) deposits. Interfingering was also observed in S12 (fig. 8d).

Depositional elements

The lateral and vertical distribution within measured sections and mapped areas of the seven depositional facies were the basis for defining six significant depositional elements used to reconstruct the Plio-Pleistocene depositional history and paleogeography of the central Duncan basin (fig. 7b). These elements constitute the significant sediment contributors that filled the Duncan basin from the Pliocene through the early Pleistocene. The six depositional elements include: *streamflood-dominated alluvial fans (Facies 1 – 3), distal sheetflood alluvial fan (Facies 4), axial braided fluvial (Facies 5), lacustrine fill (Facies 6), floodbasin (Facies 7), and the high basin stand (terminal Gila Group deposits).* These elements are outlined in figure 7a. What follows is a discussion of the depositional elements and depositional model presented for the Plio-Pleistocene Duncan basin.

The streamflood-dominated alluvial fans consist of Facies 1, 2, and 3. As shown in figure 4, the Western Salient and the southwestern margin regions just to the north and south of the Western Salient are composed primarily of interbedded sequences of Facies 1, 2, and 3. Calculations made from the 41 measured sections illustrate that roughly 64% of the measured sections along the southwestern margin of the Duncan basin are composed of Facies 3 deposits.

Therefore, all the alluvial fan facies in Western Salient and the southwestern margin of the basin are combined to form the streamflood-dominated alluvial fan depositional element.

The streamflood-dominated alluvial fans form four distinct fan associations along the southwest margin of the field area, based on clast assemblages, textural associations, color and relative distribution/geometry, but were all derived locally from the Peloncillo Mountains to the west. They interfingered and onlapped onto the floodbasin, prograded generally east to east-southeast, and filled the basin transverse to the basin axis (fig. 7b). The four fan associations were restricted to the Western Salient, and therefore, were topographically isolated from the axial sediments of the Duncan basin. The fan associations prograded locally around volcanic-bedrock highs within the Western Salient (figs. 8a,b).

The distal sheetflood alluvial fan deposits, located in the northern part of the field area, represent the distal end of a large axial alluvial fan system that prograded southeast along the axis of the Duncan basin (fig. 7). An axial fluvial braided stream network exhibiting large-scale bedforms also flowed southeast down the basin axis along the southwestern basin margin. Southeast paleocurrent indicators, the presence of distinctive red Proterozoic granite clasts and other Laramide-aged felsic-rich intrusive rocks found in these deposits suggest that they were primarily sourced from the structurally high Morenci block to the north of the Duncan basin. The axial alluvial fan partially deflected the axial fluvial stream network, thereby restricting the axial fluvial stream network to the southwest margin of the basin.

A large, areally extensive floodbasin occupied the central region of the Duncan basin (fig. 7) and acted as a catchment area for fine-grained sediments sourced from the alluvial fan and fluvial systems that originated both from the head of the basin and from the basin margins. The floodbasin deposits primarily consist of structureless mudstones, but occasionally are punctuated by soil horizons, and laterally continuous very fine- to coarse-grained channel and sheetflood sandstones. Parts of the floodbasin near Duncan were occupied intermittently by extensive freshwater lakes with benthic conditions that supported diatom growth. Lakes 5 m deep or less (depth estimate based on absence of deeper water diatoms in the lacustrine diatomaceous sediments) occupied the lower portion of the field area at least five times during the Plio-Pleistocene (fig. 7) (E. Theriot, U. of Texas, Dept. of Biological Sciences, oral communication, 2002).

Gila Group deposition terminated with the onset of downcutting by the modern Gila River. At this time, many of the closed late Pliocene-early Pleistocene intermontane basins such as the Duncan basin stopped aggrading sediments and basin filling ceased. This point of maximum basin aggradation has been termed by Menges and McFadden (1981) as the "high basin stand" (HBS). Numerous basins in southeast Arizona have HBS deposits (including the Duncan basin), and these deposits are all very similar (Scarborough, 1989; Melton, 1965). Studies by Menges and McFadden (1981) of the Sonita Creek and Canada del Oro basins northwest of Tucson have shown that the youngest Gila Group deposits, or the HBS deposits, consist of marginal alluvial fan sequences and/or pediment gravels.

A distinct coarsening-up sequence of gravels and sandstones above the highest modern Gila River terraces represent the upper fill HBS depositional element of the Gila Group in the central Duncan basin. The HBS deposits cap several flat-lying mesas of similar elevations (between 1200 – 1300 m) along the northeast basin margin mountain fronts (figs. 7a, 8c). Based on the stratigraphic positioning above modern river terrace and alluvium deposits, the lack of deformation, sediments covering basin-bounding faults that ceased activity between 6 – 3 Ma (Menges and McFadden, 1981), and mature soil development, it is suggested that these deposits mark the termination of Gila Group deposition between the latest Pliocene and early Pleistocene (2.0 – 1.0 Ma) (Menges and McFadden, 1981; Scarborough, 1989). Their origin is most likely related to climatic and tectonic adjustments occurring near the Plio-Pleistocene boundary (Menges and McFadden, 1981).

AGE OF THE GILA GROUP IN THE CENTRAL DUNCAN BASIN

A Blancan-aged horse molar, *Equus simplicidens,* found in measured section S38 (figs. 4 and 6) can be used as a proxy for the time of deposition of the Upper Gila Group in the central portion of the Duncan basin. Based on paleomagnetic analysis integrated with biostratigraphy of the Blancan vertebrate faunas found in the Duncan basin, Tomida (1987) concludes that Section #2 and #3 from his study (shown in fig. 1) show an age-range between 3.7 - 3.1 Ma. Based on similar elevations and lithologies, sections S38 and S39 of this study are stratigraphically equivalent to Section #2 of Tomida (1987). Therefore, it can be inferred that the Gila Group deposits found in S38 and S39 (i.e., the sediments around Duncan) are between the ages of 3.7 and 3.1 Ma (i.e., early to late Pliocene). However, by correlating the horse molar (at 37.4 m) to the closest section (#3) of Tomida (1987) it is possible to constrain the age of the horse molar to between 3.3 and 3.1 Ma.

S38 is approximately at the same stratigraphic level as the streamflood dominated alluvial fans in the Western Salient (fig. 6). Therefore, the age of most of these fans is likely Pliocene as well (i.e., between 3.7 and 3.0 Ma). Moreover, interfingering of Fan association #3 with Facies 6 and 7 in S12 suggests that deposition of Fan association #3 was active approximately at the same time as the deposition of Facies 6 and 7 in S12 (fig. 8d).

As shown in figure 6, the top of S40 is at 1223 m, and the location of the *E. simplicidens* molar in S38 is at approximately 1127 m. The upper elevation of Gila Group deposits along the northeastern margin (i.e, HBS deposits) varies between 1200 – 1300 m, and this elevation approximates the Plio-Pleistocene boundary. Therefore, the Gila Group deposits that lie above S38 and below S40 in figure 6 represent the rest of the upper Pliocene section.

CONCLUSIONS

The Upper Gila Group exposed in the central Duncan basin is composed of a laterally and vertically heterogeneous package of interfingering alluvial, fluvial and lacustrine deposits that filled the basin during the early Pliocene to the early Pleistocene. A facies classification composed of seven unique depositional facies provided the basis for determining six primary depositional elements that filled the Duncan basin during the Plio-Pleistocene. A large, fine-grained floodbasin is the most significant depositional element in terms of both volume and distribution. Parts of the floodbasin were occupied at least five times by shallow freshwater ephemeral lakes. A large axial alluvial fan and an axial fluvial system prograded off of and were sourced from the structurally high Morenci block located at the NW end of the basin. Streamflood dominated alluvial fans were prevalent along the SW margins of the field area, formed four unique fan associations, and generally prograded E to ESE. The coarse-grained HBS deposits signified the final deposits of the Upper Gila Group, and were deposited at the Plio-Pleistocene just prior to downcutting by the modern Gila River. A Blancan aged horse molar helped correlate this study to others, and helped establish that the majority of the Gila Group deposits in the central Duncan basin are late Pliocene to early Pleistocene (~3.7 – 1.0 Ma).

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