QUATERNARY STRATIGRAPHY AND TECTONICS, AND LATE PREHISTORIC AGRICULTURE OF THE SAFFORD BASIN (GILA AND SAN SIMON RIVER VALLEYS), GRAHAM COUNTY, ARIZONA

FRIENDS OF THE PLEISTOCENE,
ROCKY MOUNTAIN CELL 46TH FIELD CONFERENCE
and
ARIZONA GEOLOGICAL SOCIETY FALL FIELD TRIP, 2002
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GUIDEBOOK CONTENTS

Contributed papers

INTRODUCTION

This guidebook accompanied the 46th annual meeting of the Rocky Mountain Cell of the Friends of the Pleistocene (FOP) and the 2002 Fall Field Trip of the Arizona Geological Society. The meeting and field trip were held in the Safford Basin, southeastern Arizona. The Friends of the Pleistocene is an informal gathering of Quaternary geologists, geomorphologists, and pedologists who meet annually for a field conference.

The first part of the guidebook consists of road logs with descriptions of stops covering the three days of the field trip. An overview of the geology of the Safford Basin is given in Stop 1-1. The second part of the guidebook consists of four short papers that discuss adjacent areas or that expand upon the road log descriptions of the field trip stops. The first paper by Reid and Buffler is a summary of upper Cenozoic depositional facies in the Duncan Basin, the first basin to the east of the Safford Basin. The next three papers expand upon (1) the soil study of the gridded field agricultural complex (Stop 2-3, Homburg and Sandor), (2) the vertebrate fossils of the San Simon Valley in the southeastern part of the Safford Basin (Stop 3-1, Thrasher), and (3) paleoIndian irrigation systems and settlements in Lefthand Canyon at the foot of the Pinaleno Mountains (Stop 3-2, Neely and Homburg).

Acknowledgements

This field trip was supported by the Arizona Geological Society, the U.S. Geological Survey, Safford Office of the Bureau of Land Management, and the Arizona Geological Survey. Suzzane Fish and Paul Fish (Arizona State Museum), and William Doolittle (University of Texas, Department of Geography) provided valuable archaeological insight at the gridded field paleoagricultural site Stops 2-3 and 2-4. The guidebook benefitted from the review of Dean Kleinkopf.

ROAD LOG

FIRST-DAY ROAD LOG, OCTOBER 11, 2002

Geology of the southwest side of the Safford Valley--
Pinaleno Mountains piedmont, 111 Ranch subbasin, Bear Springs subbasin

Mi.	Description
0.0	Depart from Bureau of Land Management (BLM) parking lot located on the northeast corner of 14th Ave. and 8th St. in Safford. Go east on 8th St. 1.0 mi to U.S. 191.
1.0	Turn south on U.S. 191.
2.8	Foot of the erosional scarp separating the Holocene Gila River flood plain on the north from the Pleistocene Gila River alluvial terrace on the south. The scarp is commonly 6 to 18 m high and the terrace alluvium is 0 to 15 m thick. Drillers' logs indicate that the alluvium in the flood plain also is a maximum of about 15 m thick. There are numrous small gravel pits on the terrace and a few large ones, such as the Morris Company pit on the east side of the road 0.2 mi south of the crest of the scarp. The river gravel being quarried is relatively clean and well sorted with little or no overburden and is thus a valuable commodity. Detailed mapping showed that the band of Pleistocene Gila River alluvium on the terrace on the south side of the flood plain is 0.8 to 4.0 km wide (Houser and others, 1985), unconsolidated but locally calcite cemented at the base.
3.6	Approximate southern extent of Gila River terrace gravel beneath a veneer of Pleistocene piedmont alluvium (Houser and others, 1985).
4.8	Cross the Cactus Flat Fault zone. The fault zone here is about 0.4 km wide and trends N47°W (Houser and others, 1985; Machette and others, 1986). Its trace is inferred from prominent vegetation lineaments on aerial photographs. Although currently, there

is no visible offset or disturbance of the Pliocene 111 Ranch Formation (basin fill) or the overlying veneer of Pleistocene piedmont alluvium in the roadcuts, Machette and others (1986) reported seeing faults in these roadcuts that offset Pliocene basin fill and lower to middle Pleistocene Gila River terrace alluvium, but not upper Pleistocene piedmont alluvium. On this basis, they assigned a middle Pleistocene age to the youngest movement of the faults. Mapping by Houser and others (1985) shows that Machette and others (1986) mistakenly indentified the Pliocene 111 Ranch Formation as Pleistocene Gila River terrace alluvium and thus, the only constraints on the age of faulting at this locality are the faulted Pliocene basin fill and the undisturbed upper Pleistocene piedmont alluvium.

5.7 Entrance to Roper Lake State Park on the east.

8.6 Junction with AZ 366 (Swift Trail). Turn right (southwest) on AZ 366.

11.9 Cross the North Safford Fault zone (Machette and others, 1986).

14.5 Turn right on dirt road. There are some really nice exposures of the internal framework of the proximal facies of a Pleistocene alluvial fan near the beginning of this dirt road. We are not stopping here, however, because we will observe similar features at Stop 1-4 at Frye Mesa. Remnants of the Pleistocene alluvial fans extend up the northeast side of this part of the Pinalenos to elevations ranging from 1,460 to 1,585 km. Deep canyons, such as Jacobson Canyon south of AZ 366, that have eroded down to bedrock along the sides of the fans show that many of the fans were deposited in pre-existing canyons. The pre-existing canyons may be late Pliocene and (or) may have been eroded, then filled and exhumed several times during the Pleistocene chiefly as a result of climate fluctuations.

15.7 Proceed 1.2 mi to an overlook and park by the stone wall.

STOP 1-1. Overview of Safford Basin (Brenda B. Houser)

Previous work. Earlier studies of the Safford Basin have dealt almost exclusively with the Tertiary basin-fill rocks (Knechtel, 1938; Harbour, 1966; Houser and others, 1985) or with

Pliocene vertebrate fossils and stratigraphy (Galusha and others, 1984, Lindsay and others, 1987). Richter and others (1983) and Houser and others (1985) mapped Quaternary piedmont alluvium and alluvium of the Gila River and smaller washes in the Guthrie and Safford quadrangles but did not discriminate between the various ages of the Pleistocene deposits. No surficial maps of the Safford Basin have been prepared. Machette and others (1986) and Pearthree (1986) discussed Quaternary faulting in Arizona and parts of New Mexico and showed several fault locations in the Safford Basin. The geothermal energy resources of the basin were described and discussed by Stone and Witcher (1982, Mexican Highland section).

Geologic setting. The Safford Basin is near the middle of a northwest- to north-trending extensional basin that is more than 300 km long, extending from Globe, Arizona to beyond the Mexican border. The Safford Basin is bounded on the northeast and east by the Gila, Peloncillo, and Whitlock Mountains (fig. 1), which consist mostly of middle Tertiary volcanic rocks, with minor Laramide volcanics and intrusive stocks in the Gila Mountains. On the southwest, it is bounded by the predominantly Precambrian granitic rocks of the Pinaleno Mountains metamorphic core complex (Thorman, 1981) and Tertiary granitic rocks of the Santa Teresa Mountains (Simons, 1964). The southeastern part of the basin is drained by the San Simon River and Stockton Wash, both of which have intermittent flow. The northwestern part is drained by the perennial Gila River.

The ages of the volcanic rocks in the mountains on the north and east indicate the Safford Basin began to form about 17 Ma. This age is bracketed by the youngest middle Tertiary volcanic rocks of intermediate composition and the oldest lava flows of basaltic composition, which indicate the beginning of Basin and Range crustal extension (Richter and others, 1983). The basin was filled with as much as 4,600 m of fluvial, playa, and lacustrine sediments (Kruger, 1991). With the exception of tephra beds, there are no exposures of volcanic rocks interbedded with the basin fill.

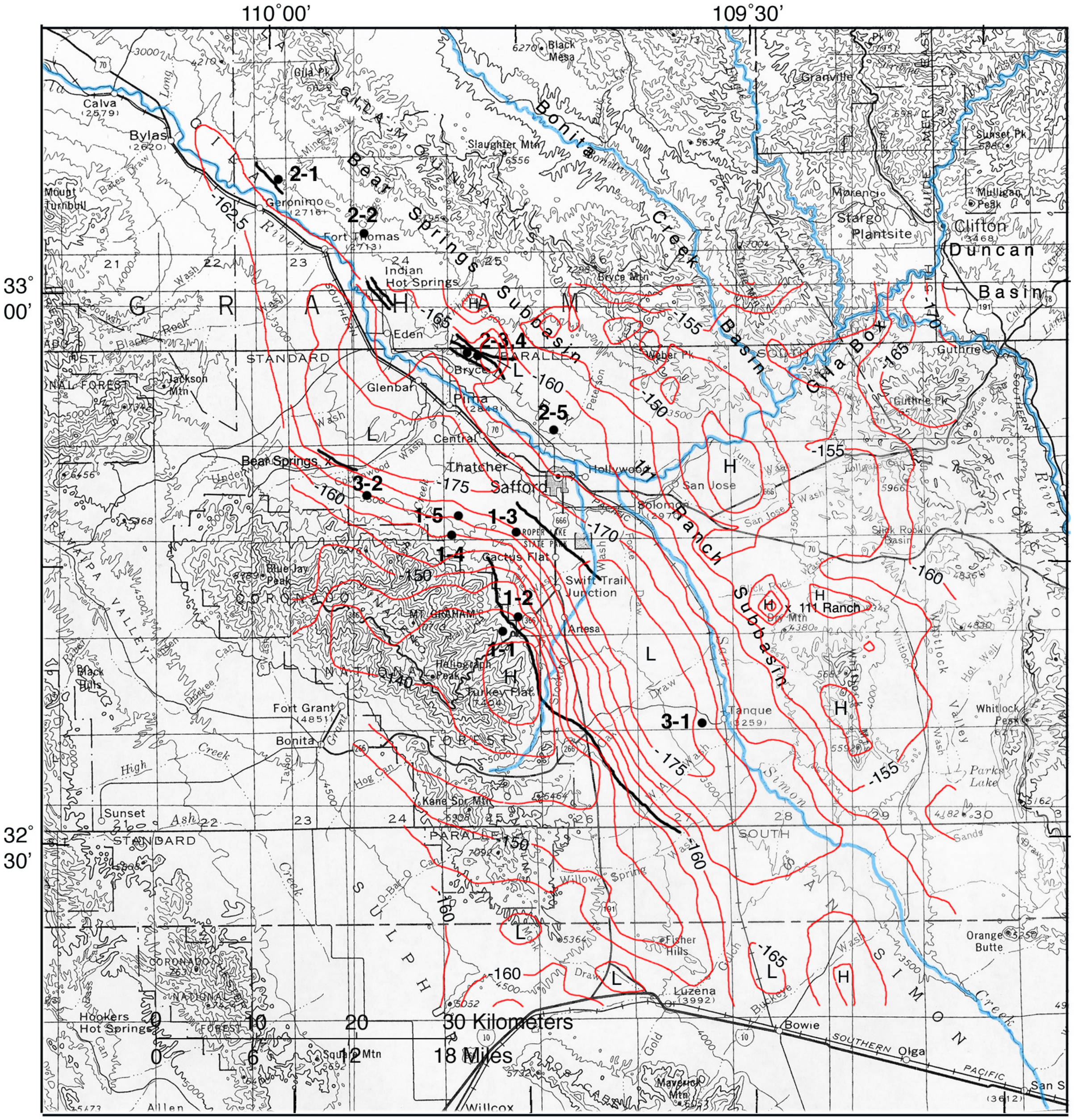


Figure 1. Map showing the Safford Basin and subbasins, adjacent mountain ranges, and major streams (blue lines). Field trip stops are shown by filled circles; faults are shown by heavy black lines. Complete Bouguer gravity anomaly contours are shown in red (contour interval is 5 milligals). Gravity data east of 110° longitude and south of 33° latitude are from Wynn (1981). Gravity data west and north of 110° and 33° are from Andrew Griscom, unpublished data. Note that the highway labeled U.S. 666 is now U.S. 191.

Stratigraphy. As in other basins in southeastern Arizona and southwestern New Mexico, the basin-fill sedimentary rocks of the Safford Basin were deposited in two distinct packages separated by a substantial hiatus (Menges and McFadden, 1981: Houser, in press). The older lower basin-fill unit is the Miocene Midnight Canyon Conglomerate, probably deposited between 17 to 10? Ma, which is exposed in lower Bonita Creek Basin and at the mouth of the Gila Box (fig. 1) (Richter and others, 1983: Houser and others, 1985). The younger upper basin-fill units are the Pliocene 111 Ranch Formation, the Bear Springs deposits (both probably 6? to about 2 Ma), and an overlying unmapped Pliocene or lower Pleistocene unit (Richter and others, 1983; Houser and others, 1985). The upper basin fill is exposed all across the Safford Basin beneath Pleistocene deposits.

Deposition of basin-filling sediments ceased when subsidence of the basin waned and through-flowing drainage was established after about 2 Ma. The unnamed unit may record the beginning of the transition from a closed basin to through-flowing drainage. This younger unit contains obsidian, which is not present in older units, but does not contain the rest of the suite of distinctive clasts carried by the Gila River. The obsidian probably was derived from the Eagle Creek and San Francisco River drainage basins northwest and north of Clifton-Morenci (fig. 1). In the Safford Basin the obsidian-bearing younger unit, which was not mapped separately, overlies the Pliocene 111 Ranch Formation and has the same distribution (see next section). At the northwestern end of the Duncan Basin (the next basin to the east of the Safford Basin) the obsidian-bearing unit was mapped as the beds of Smuggler Canyon (Richter and others, 1983; Ferguson and Enders, 2000). The presence of the younger unit in both basins suggests that integration of the drainage, prior to the arrival of the Gila River, began with streams from the north entering the Duncan Basin and flowing southwestward in the gap between the Gila and Peloncillo Mountains (ancestral Gila Box) to the Safford Basin.

The Pleistocene units of the Safford Basin consist of Gila River terrace alluvium, which contains a bed of the ~0.64 Ma Lava Creek B ash-fall tuff (Lanphere and others, 2002) on a terrace about 24 m above the elevation of the present river (Stop 2-5), and piedmont alluvium derived from the Gila, Peloncillo, and Whitlock Mountains on the north and east and the Pinaleno and Santa Teresa Mountains on the southwest. Holocene alluvium is present in washes and in the Gila River flood plain. The Gila River terrace alluvium always directly overlies basin-fill units. The piedmont alluvium overlies either basin fill or Gila River terrace alluvium; there is little or no interfingering of the piedmont and Gila River alluvium. The oldest Gila River alluvial deposits occupy a belt of terraces about 5 km wide on the north side of the river where it enters the basin (Houser and others, 1985). Since 0.6 m.y. ago however, the river seems to have remained within the lateral bounds of the present Holocene flood plain.

Structure. Generalized Bouguer gravity anomaly contours (Wynn, 1981) are shown on figure 1 to indicate the shape of the Safford Basin and its two subbasins. The gravity data and Vibroseise seismic reflection data (Kruger, 1991) show that the Safford Basin is a half graben with its deep side on the southwest next to the Pinaleno Mountains, overlying the Pinaleno Mountain detachment fault (Thorman, 1981). The basin consists of two subbasins; the southern one is between Cactus Flat and Tanque and the northern one lies between Thatcher and Fort Thomas (fig. 1). Safford is near the middle of the saddle separating the subbasins. A core taken at the bottom of a deep water well south of Thatcher showed the saddle is underlain by granite at a depth of only about 760 m whereas seismic reflection data show the southern subbasin is as deep as 4,600 m (Kruger 1991). Thus, the relief on the bedrock surface at the bottom of the basin is substantial, at least 3,500 m.

The southern subbasin was named the 111 Ranch subbasin for the Pliocene vertebrate fossil locality located near Dry Mountain (fig. 1) on the eastern side of the subbasin (Houser, 1990). In the same paper (Houser, 1990), the northern subbasin was named the Bylas subbasin, however, this subbasin is herein renamed the Bear Springs subbasin for springs located near the center of the subbasin.

An important aspect of the subsurface shape of the Safford Basin is the correspondence between the surface traces of Quaternary faults and the shapes and locations of the deeper parts of the subbasins (fig. 1). The Safford Fault zone (Stop 1-2) (fig. 2) parallels the western edge of the 111 Ranch subbasin and terminates at the northern end of the subbasin. The Cactus Flat Fault lies along the crest of the saddle between the two subbasins. The faults we will see at Stops 2-1, 2-3, and 2-4 lie along the northeastern edge of the Bear Springs subbasin.

The broad alluvial plains at the lower reaches of the streams that drain the northeast side of the Pinaleno Mountains are evidence of continuing subsidence of the underlying Bear Springs subbasin. Where the course of the northeast flowing streams is above the northeast sloping side of the subbasin, the width of their valleys occupied by Holocene alluvium is less than 0.4 km. The valley widths widen abruptly to as much as 4 km where the streams cross the axis of the underlying subbasin and flow above the southwest sloping side of the subbasin. This suggests that the gradients of the northeast flowing streams are increased above the northeast sloping side of the subbasin and (or) reduced above the southwest sloping side. Clearly, the tectonic forces that have shaped the Safford Basin over the past 17 Ma are still at work, although at a reduced intensity.

Return to vehicles.

19.5 Retrace route back to the North Safford Fault zone and turn north (left) off of Swift Trail (SR 366) on paved road just southwest of Cyclone Hill (FR 57).

19.6 Cross cattleguard where pavement ends. We are driving on the uppermost part of an extensive late Pleistocene to Holocene alluvial-fan complex derived from Jacobsen Creek and lesser drainages. Note that the surface dirt is brown to light orange, local surface topography is quite rough, and the boulders on the surface are generally weathered very little.

19.9 Stay on main gravel road by taking a hard right turn.

20.1 Note oxidized gravel exposed in the roadbed as the road turns to the left. These deposits are older than most of the surficial deposits that mantle this part of the piedmont, and may be quite old. Note the character of much younger deposits immediately north of this site.

20.2 Cross cattleguard.

20.5 Bouldery, relatively young alluvial-fan deposits are evident on the east side of the road here. Note the boulder train that is probably a relict debris flow levee. These deposits were probably mainly emplaced by debris flows.

20.8 As we round a broad right bend in the road, a rounded ridge of older fan deposits (unit QTs) is visible in the near distance to the northeast. Part of the younger (but still quite old) alluvial fan that we will be examining in more detail is visible to the right of the QTs ridge.

21.3 There is a nice exposure of bouldery terrace deposits of probable Holocene age along Swift Canyon Wash on the north side of the road. The active channel of the wash is incised several meters below the terrace surface.

21.9 Pull off to the right side of the road at the sharp left bend in the road. We are now on a remnant of a Pleistocene alluvial fan that has been displaced by late Quaternary faulting. The fault scarps on the fan surface are about 500 m downslope to the east.

Walk down to the east on the bouldery relict alluvial-fan surface for about 500 m (1/3 mile). The fence you will encounter marks the boundary between National Forest land and state land. The fault scarps are just east of the fence.

STOP 1-2. North Safford Fault zone (Phillip A. Pearthree)

At this stop, we will examine a site where the Quaternary fault scarps that trend north to northwest along the eastern front of the Pinaleno Mountains are fairly obvious. The particular fault scarps we will visit are formed on a Pleistocene alluvial fan remnant derived from Marijilda Canyon. In this area, well-preserved, planar middle(?) Pleistocene fan surfaces have been displaced several meters across the fault zone. In the same area, there are no obvious fault scarps formed on Holocene deposits, which implies that the age of the youngest fault rupture is at least pre-Holocene. At other places along the fault zone, however, deposits as young as late to latest

Pleistocene are faulted. Analyses of fault scarp morphology also suggest that the youngest fault rupture occurred in the latest Pleistocene, and that the middle Pleistocene fan surfaces have been displaced by at least two faulting events. We will examine the fault scarps, have a look at the characteristics of faulted and unfaulted surfaces, and briefly consider the Quaternary geomorphic evolution of this part of the Safford basin.

Geologic and Geomorphic Character of Quaternary Faulting. Quaternary fault scarps parallel the north to northwest trend of the east side of the Pinaleno Mountains (fig. 2). Scarps are very close to the steep, fairly linear mountain front along the northern section of the fault. The sharpness of the northeastern front of the Pinaleno Mountains suggests a fairly active normal fault, but this morphology is likely due in part to the resistant gneissic rocks of the metamorphic core complex that are exposed there. Along the southern part of the fault, scarps are several kilometers east of the topographic mountain front (fig. 1) and are likely near the edge of an extensive pediment. Quaternary displacement appears to diminish to nothing at the southern end of the fault zone, but the northern end of the fault zone may interact with other zones of deformation mapped by Houser (1985; 1990). Fault scarps are near the western margin of a middle and late Cenozoic sedimentary basin that is up to 3000 m deep. Seismic reflection lines suggest that the fault zone dips moderately steeply in the shallow subsurface (~50°). The fault zone appears to merge downward into a major, low-angle (~20° below 2-3 km), northeast-dipping detachment fault which projects beneath the transition zone between the Basin and Range and the Colorado Plateau (Kruger, 1991). Total down-to-the-northeast displacement across the detachment is at least 7 km (Naruk, 1987).

All along the Safford fault zone, low to moderately high fault scarps are formed on Pleistocene relict alluvial-fan surfaces. Holocene deposits evidently are not faulted (fig. 3). In a few places, late Pleistocene fans are offset about 1 to 2 m. More commonly middle Pleistocene fans are offset 2 to 5 m. Maximum slopes on fault scarps range from about 5° to 20°, and typically are steeper along the northern part of the fault zone where scarps are formed in coarse

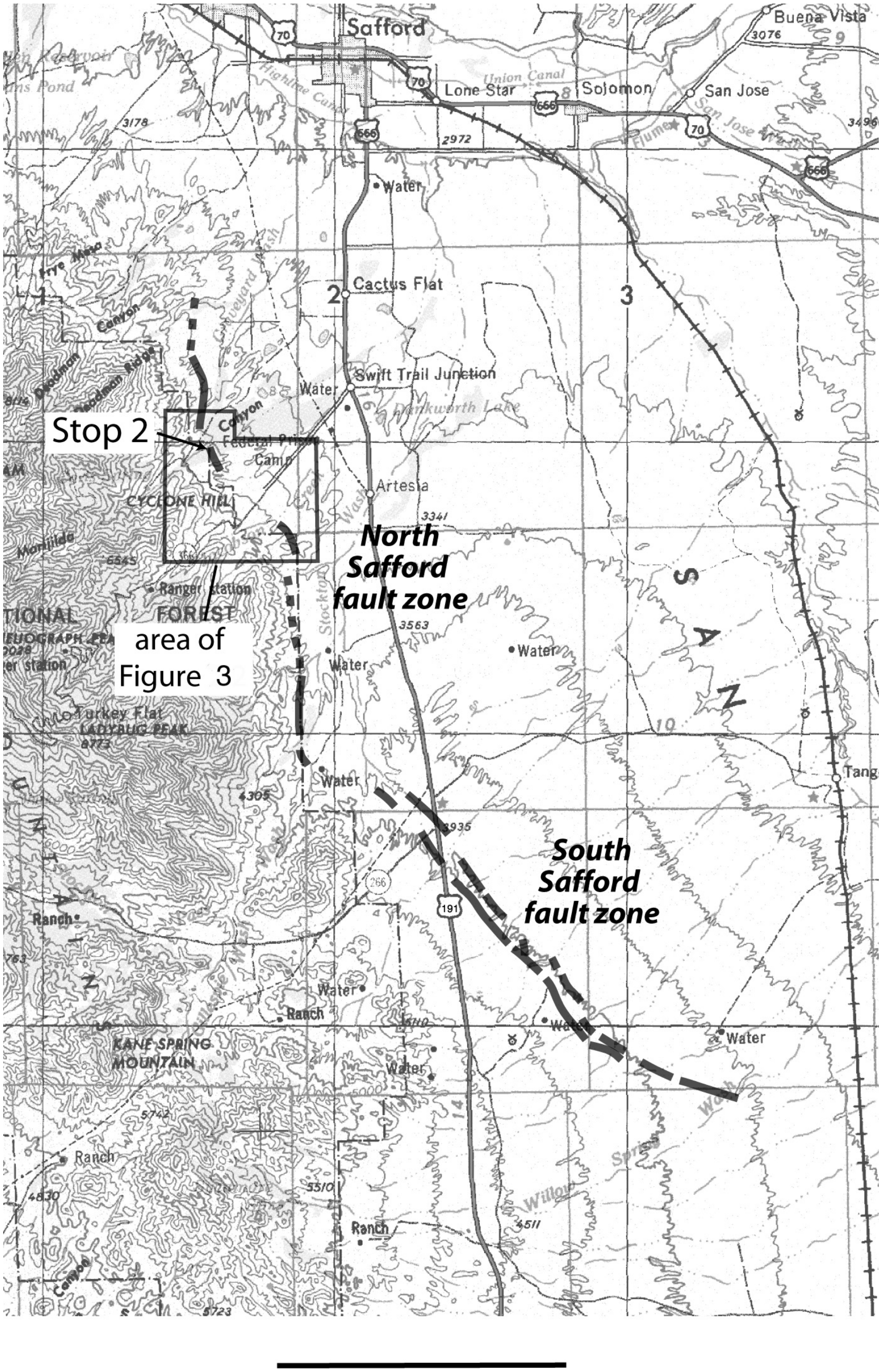
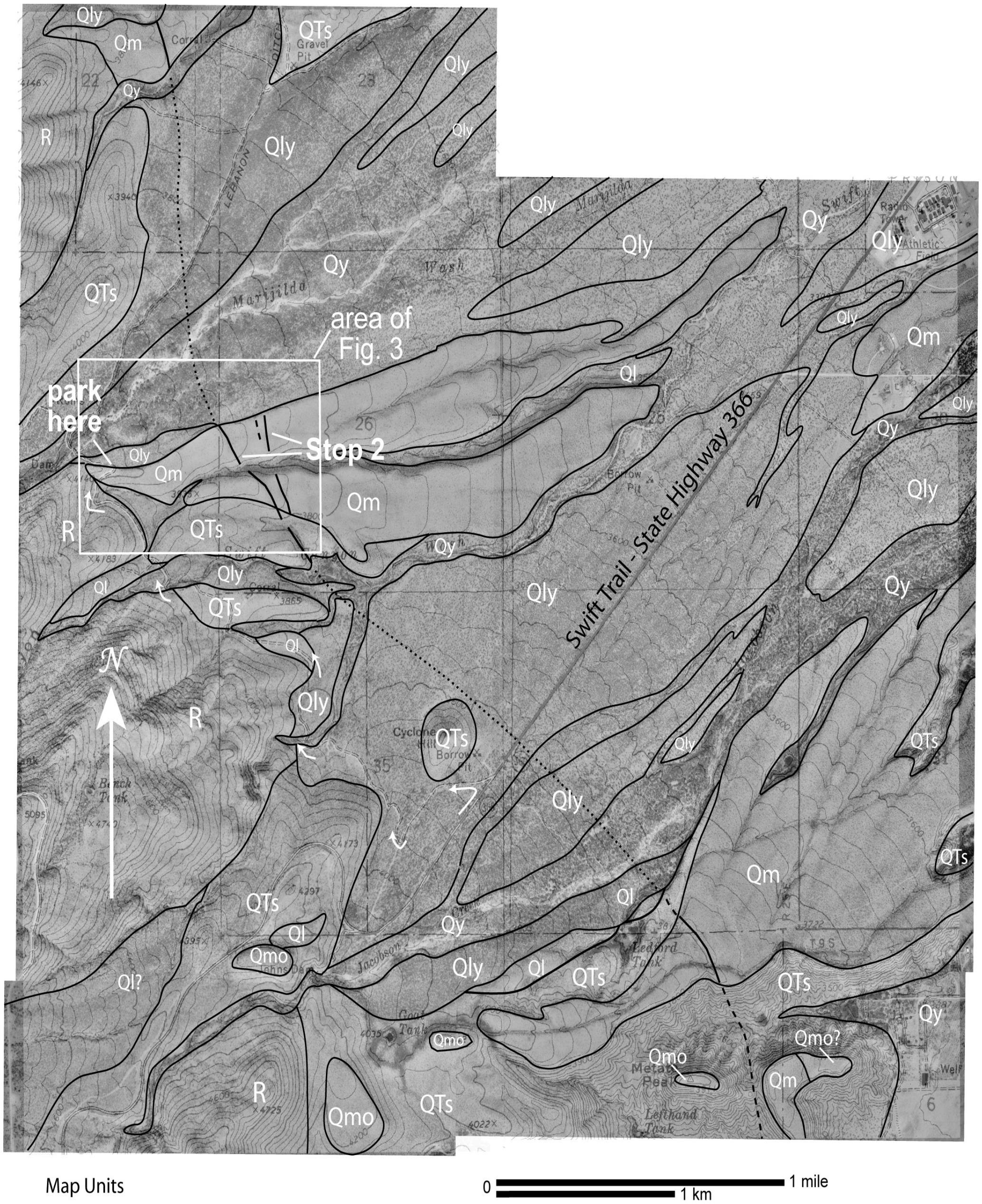


Figure 2. Location map for the Safford Fault zone. The fault zone is subdivided into north and south sections based on different trends and locations relative to the mountain front. Both sections ruptured most recently in the late to latest Pleistocene, possibly in one large earthquake. There is also evidence for recurrent Quaternary fault movement on both sections.

alluvial fan deposits. Morphologic analyses of fault scarps suggest a late to latest Pleistocene age of youngest rupture along the fault (Menges and Pearthree, 1983; Machette and others, 1986). Profiles of scarps formed on middle Pleistocene fan surfaces typically have steeper sections that likely record a fairly young faulting event. These steeper sections are near the much broader and more eroded scarps formed after at least one earlier faulting event.

Clues to the Age and Character of Quaternary Faulting. At our field site, we can consider some of the evidence that is used to estimate the age and character of Quaternary faulting in the Basin and Range Province. The fault scarps cutting a middle(?) Pleistocene alluvial fan are fairly obvious (fig. 4), and we can examine the morphology of the principal fault scarp, the surface and soil characteristics of the faulted alluvial fan, the erosional and deposition impacts of faulting, and the extent of deformation of the fan surface. We can also consider the relative impact of faulting on the landscape compared with the long-term downcutting in the basin driven by external base-level fall.

Relatively planar fluvial landforms such as well-preserved relict alluvial fans and terraces are excellent recorders of fault displacement. First, because they are such planar features, it is relatively easy to detect the changes in surface slope associated with fault scarps. You should find that to be the case at this site. It is much more difficult to detect fairly small amounts of fault displacement of younger surfaces in this environment because of their relatively rough surfaces. The depositional surfaces of faulted landforms once were continuous across the fault zone, with uniform or gradually varying slopes, and they were subsequently displaced. Therefore, long topographic profiles that approximately follow the gradient of the depositional surface can be used effectively to estimate the total displacement. It is important that these profiles be relatively long in order to characterize the original depositional surface both above and below the zone of fault deformation, which may be hundreds of meters wide in some cases. At this site, the relict Pleistocene fan surface is displaced 3 to 4 m down-to-the-east across the fault zone. Increasing displacement of progressively older surfaces is evidence of recurrent Quaternary fault



Map Units

Qy - Holocene channel, terrace, and alluvial fan deposits
Qly - Holocene to latest Pleistocene alluvial-fan and terrace deposits
Ql - late Pleistocene alluvial fan and terrace deposits
Qm - middle Pleistocene alluvial fan deposits
Qmo - middle to early Pleistocene remnant fan deposits
QTs - early Pleistocene to Pliocene alluvial deposits
R - undifferentiated bedrock

\ Quaternary fault, dashed where uncertain, dotted where concealed

Figure 3. Preliminary surficial geologic map of the Swift Trail area. The map is based almost entirely on interpretation of color aerial photographs, with very limited field checking. Age estimates for map units are approximate. The Safford Fault zone cuts middle(?) Pleistocene and older deposits, but evidently does not displace Holocene to latest Pleistocene fan deposits.

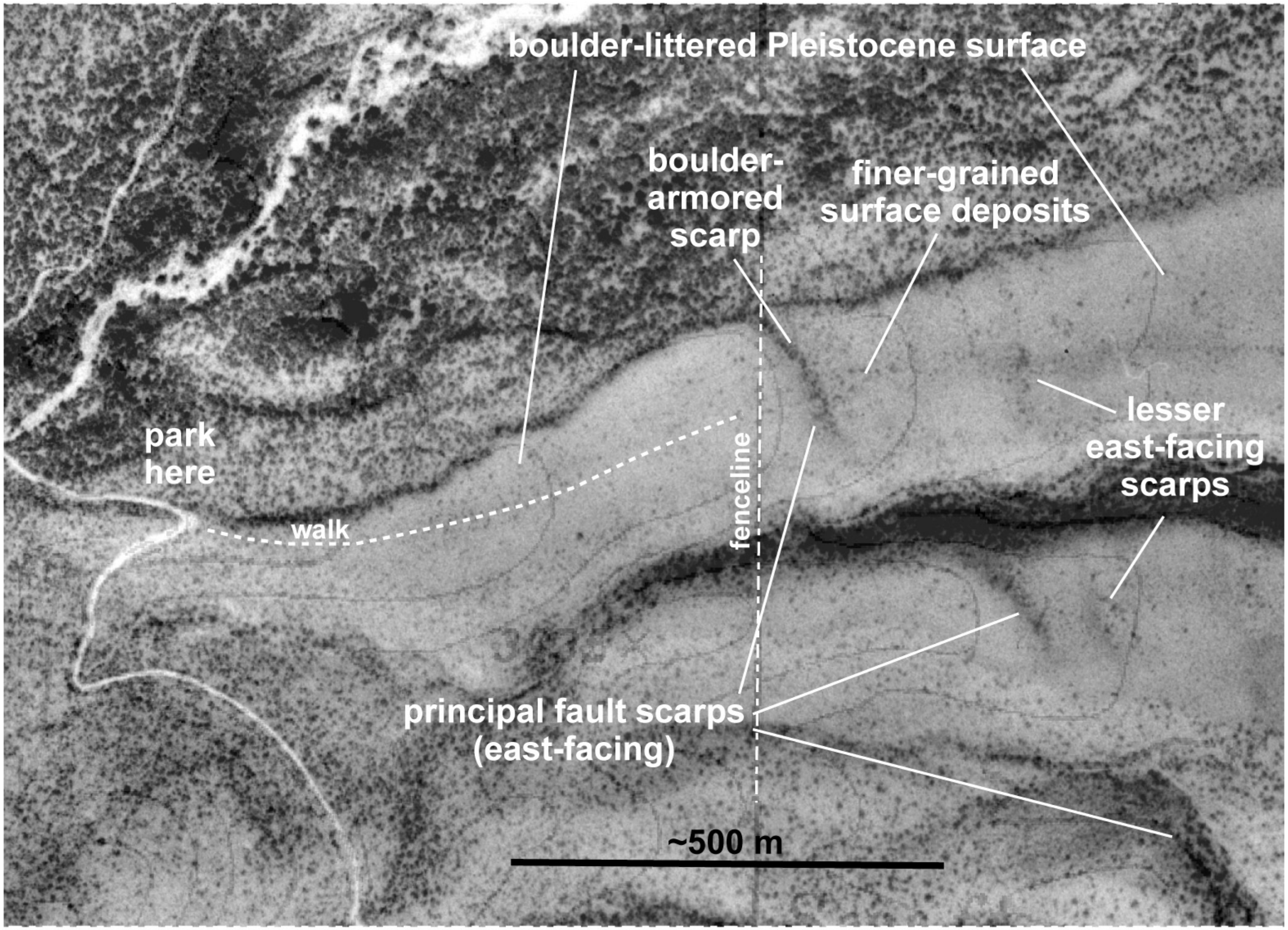


Figure 4. Larger scale aerial photograph of the area of Stop 1-2. Hike down to the Qm surface from the road to examine the fault scarps discussed in the text.

movement. There are relict alluvial deposits and surfaces in this area that are much higher and older than the surface at this field site. They are poorly preserved, however, and cannot be used with any confidence to estimate longer-term fault displacement.

The shape or morphology of fault scarps may provide much useful information regarding the age of youngest fault rupture and whether there has been repeated fault rupture. Scarps formed in alluvial-fan deposits by a large, surface-rupturing earthquake typically have maximum slope angles of 60° to 90°. Over a period of tens to hundreds of years, these slopes degrade by mass failure to the angle of repose for the alluvial material, typically around 35°. After that time, scarp slopes decrease much more slowly, such that it likely takes thousands of years for a scarp to degrade to 25° and tens of thousands of years to degrade to 5°-10° (Wallace, 1977). As maximum scarp slopes decrease, the crest and toe of the scarp migrates away from the fault zone. Thus, fault scarps become increasingly wide and less steep with time. Because fault scarps evolve somewhat predictably after a surface rupture, they provide a rough measure of the time since the fault last ruptured. Morphologic analyses of the Safford fault scarps suggest that the fault ruptured most recently in the late Pleistocene. In addition, the central parts of some scarps exhibit marked increases in slope that suggest the fault has ruptured repeatedly. That is likely the case at Stop 2.

Quaternary geologists use a variety of relative and numerical methods to map alluvial surfaces and estimate their ages. Radiocarbon dating and the presence of cultural artifacts may be used to date Holocene and latest Pleistocene alluvial deposits. It is very difficult to date older Pleistocene alluvial deposits precisely in this environment. Typically, surface and soil characteristics are used to correlate alluvial surfaces to other, better-dated surfaces in a region. Characteristics typically used include clay and carbonate accumulations in soils, soil and surface color, surface topography, drainage network development and incision into the surface, and the topographic position of the surface in the landscape. In southeastern Arizona, we are fortunate in that our environment that is quite similar to that of the extensively studied deposits and soils of the Desert Project near the Las Cruces, New Mexico (Gile and others, 1981). We roughly estimate the ages of alluvial surfaces in this region by correlating them with each other and with the surfaces of the Desert Project. On the basis of such correlation, we estimate that the Qm surface we are on is perhaps 100,000 to 500,000 years old (fig. 3). In this vicinity, there clearly are deposits and that are much older (Qmo, QTs). In the case of deposits mapped as QTs, the original depositional surface has been completely removed by erosion. There are also extensive young deposits associated with the larger canyons in the Pinaleno Mountains. Contrast the character of the faulted Qm surface with the unfaulted young alluvial fan (Qy) just north of the Qm surface (fig. 3).

Based on fault scarp morphology and this rough chronology of alluvial surfaces, we concluded that the Safford fault zone ruptured most recently in the late to latest Pleistocene (Machette and others, 1986). At least two faulting events have occurred in the past several hundred thousand years on the fault zone, with several meters of total displacement. The very long recurrence interval implied between faulting events is consistent with other faults that have been studied in southeastern Arizona (Pearthree, 1986). Older alluvial deposits are likely displaced by greater amounts, but displacement measurements are uncertain. The topographic relief between fairly old (Qm) and really old (Qmo and QTs) surfaces is much greater than the likely amount of fault displacement, which implies that the impacts of regional base-level fall on the landscape are far greater that the impacts from Quaternary faulting.

Return to vehicles.

27.6 Retrace route back to U.S. 191 and turn north (left) on U.S. 191.

32.7 Turn west (left) at traffic light onto Discovery Park Blvd.

34.1 Turn north (right) on 20th Ave. at T-junction.

35.0 Turn west (left) on Golf Course Road.

35.5 Inactive gravel pit on south side of road. Pit is in Gila River terrace alluvium, which here consists of alternating beds of muddy sand and pebble gravel, each about 1 m thick. Stock piles of large cobbles and small boulders indicate the presence of larger clasts in the deposit.

36.0 Turn left (south) on dirt road (opposite 1st Ave.) and go through a green gate marked Frye Mesa Ranch.

36.2 Pass a power substation on right.

36.7 Turn south (right) onto a dirt road along a power line.

36.8 Keep left at fork.

36.9 Freeman Flat on the left.

37.1 Keep left at fork

37.2 Cross under another power line; keep straight ahead.

37.4 Keep left. Crossing northwestern end of the Cactus Flat Fault zone.

37.9 Keep left.

38.1 Keep left

38.4 Keep straight (dirt road from left)

38.6 Fence; gate should be open.

38.8 Park and walk down into Freeman Wash on the east (left).

STOP 1-3. Pliocene through Holocene (?) faulting in Freeman Wash (Brenda B. Houser)

The fault zone that crosses Freeman Wash near here is located about midway between the northwestern ends of the Cactus Flat and North Safford Fault zones of Machette and others (1986) (fig. 1). It is a diffuse NW-trending zone of many faults with small offset. Its surface trace is identified by vegetation lineaments on aerial photographs, petrocalcic soils, rotated mesa caps, and faults cutting Pliocene through Holocene (?) units in the banks of Freeman Wash. This may not be a discrete zone of faulting but may be just a well-exposed example of the typical deformation in the three-mile-wide strip of piedmont slope separating the Cactus Flat and North Safford Fault zones.

At this stop we will walk down 0.8 km of Freeman Wash, perpendicular to the fault zone and see evidence for Pliocene, Pleistocene, and perhaps Holocene movement across the zone. However, exposures along the banks of the wash are unpredictable because of the poorly consolidated nature of the basin fill and especially the lack of consolidation of the Holocene alluvium. Faults can always be seen in the Pliocene basin-fill sediments and I have seen both normal and reverse faults that appear to cut the overlying Holocene alluvium, but these latter faults are not always visible.

The trace of an inferred fault within the zone is visible on aerial photographs as a 0.4-km-long, N45°W-trending vegetation lineament that crosses the road near where the vehicles are parked. There is no obvious topographic scarp and the lineament probably is caused by mesquite trees and other shrubs growing more abundantly on the upslope side of the fault where shallow ground water may be dammed by differing permeability and porosity of the rocks on either side of the fault plane, or by gouge along the fault plane. Mesquite trees in this hydrologic setting commonly have an unusual shape. They appear to be very old, very short trees (about 2 m tall) with broad crowns relative to their height. The trees have thick short trunks, on the order of 0.5 m in diameter and 0.5 m high, and long nearly horizontal limbs that rest on the ground. This growth habit makes them appear on aerial photographs as large dark spots.

The most obvious evidence for Pleistocene or younger deformation is the differing dip of two mesa caps within the fault zone on the northwest side of Freeman Wash (fig. 5). The mesas are composed of the Pliocene 111 Ranch Formation and the caps are Pleistocene piedmont alluvium. The mesa cap on the north dips about 3°NE whereas the mesa cap on the south dips about 4°SW. The average slope of the piedmont surface in the area is about 2°NE indicating that both mesas have been rotated and in opposite directions, the one on the north by 1° and the one on the south by 6°.

Two facies of the 111 Ranch Formation are exposed in this area. The red granite-bearing facies of the 111 Fanch Formation derived from the Gila Mountains and Bonita Creek (Houser and others, 1985; Houser, 1990) predominates in the two mesas, wheras the white granite-bearing facies derived from the Pinaleno Mountains (Houser, 1990) is the chief unit exposed along Freeman Wash. The Pinaleno-derived facies consists of sequences of semi-indurated, light-olive gray to greenish-gray, micaceous, feldspathic thin- to thick-bedded sandstone alternating with sequences of laminated gypsiferous silty claystone having yellowish-gray lenticular to continuous, thin limy beds and flattened calcareous concretions. The coarse-grained alluvium overlying the Pliocene Pinaleno-derived facies in Freeman Wash consists of Holocene alluvium on a narrow terrace next to the stream channel and a blanket of late Pleistocene or early Holocene alluvium across the rest of the wash.

The small scale faults and soft sediment deformation features of the fault zone are particularly obvious in claystone lithology of the Pinaleno-derived facies because of the thin light colored limy beds. Figure 6 shows typical small scale normal faults with offsets of centimeters to decimeters in the Pliocene claystone, and no apparent offset of the overlying Holocene terrace alluvium. Figure 7a shows a series of bedding plane faults or slumps in the claystone. Figure 7b shows soft sediment deformation of limy layers overlying a thin sand bed. The exposures shown in figures 7a and 7b are within about 3 m of each other and both may have formed as a result of seismic shaking during the Pliocene when the sediment was still unlithified.

Leave Freeman Wash where a dirt road comes down to the wash from the west, just south of the base of the northern mesa. Follow the dirt road back to the main dirt road and back to the vehicles.

41.6 Retrace route to junction of Golf Course Road and 1st Ave. Go north on 1st Ave. 42.6 Descend from Pleistocene Gila River terrace to Holocene flood plain.

45.1 Junction of 1st Ave. and U.S 70. Turn west (left) on U.S. 70.

46.1 Junction of U.S. 70 and Reay Lane in Thatcher. Turn south (left) on Reay Lane.

46.8 Base of Pleistocene Gila River terrace. The strip of terrace alluvium is about 0.6 km wide here (Houser, unpublished mapping).

47.4 Turn west (right) on graded road at north edge of junk yard and follow the road to the base of Frye Mesa

52.1 Park at base of Frye Mesa.

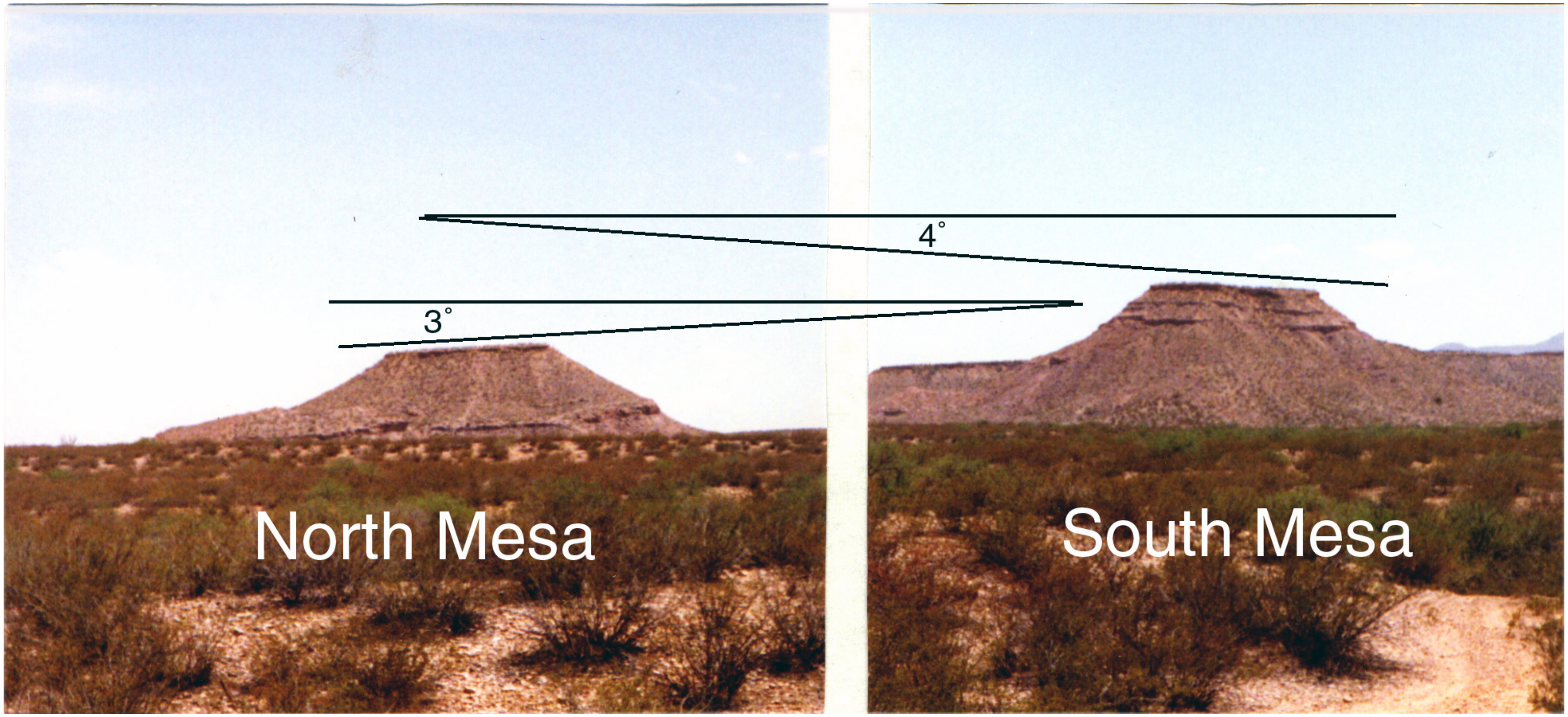


Figure 5. Photograph showing rotated Pleistocene mesa caps above the fault zone at Freeman Wash (Stop 1-3).

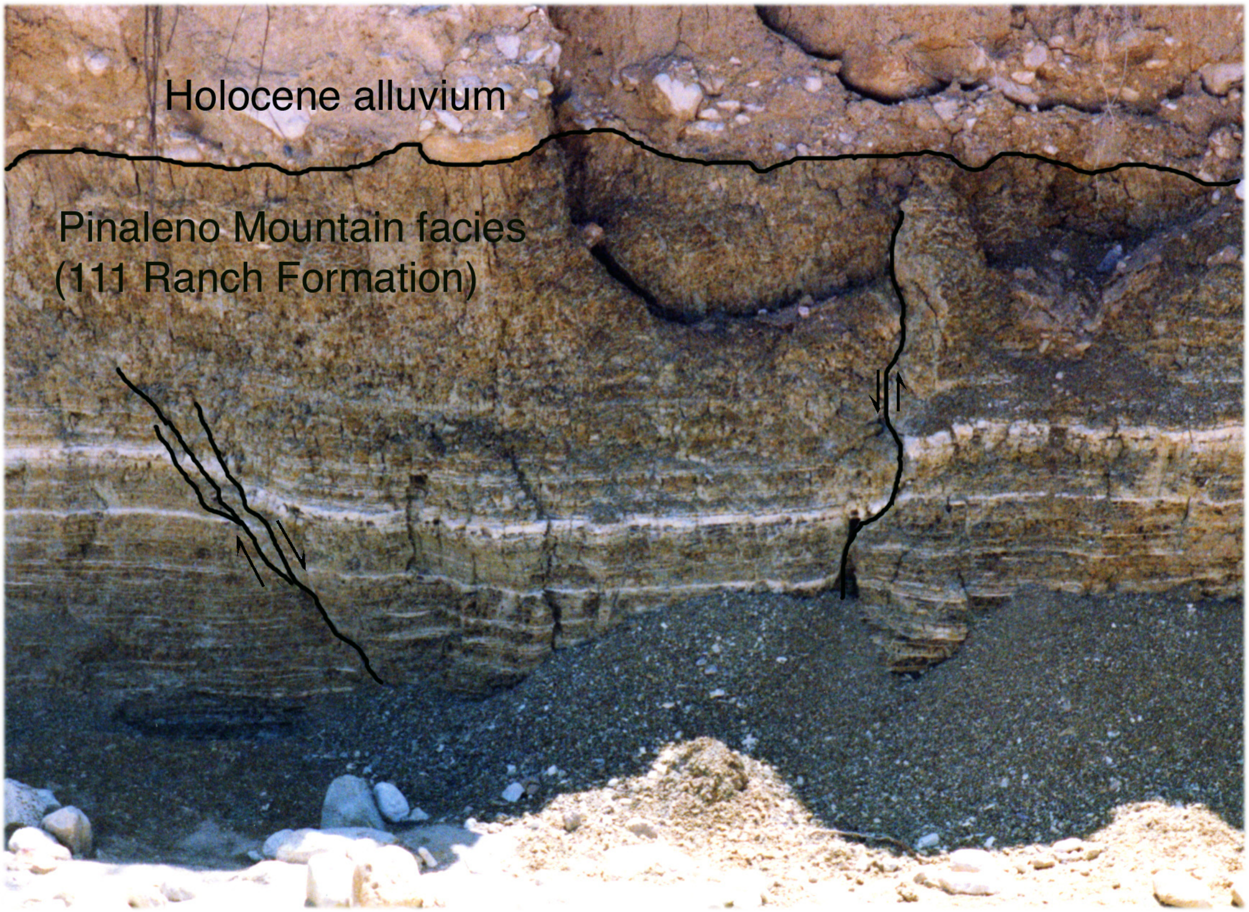


Figure 6. Photograph showing two normal faults with offsetting sense of displacement in Pinaleno Mountain facies of the 111 Ranch Formation in the fault zone in Freeman Wash (Stop 1-3). Individual displacement is about 0.2 m.

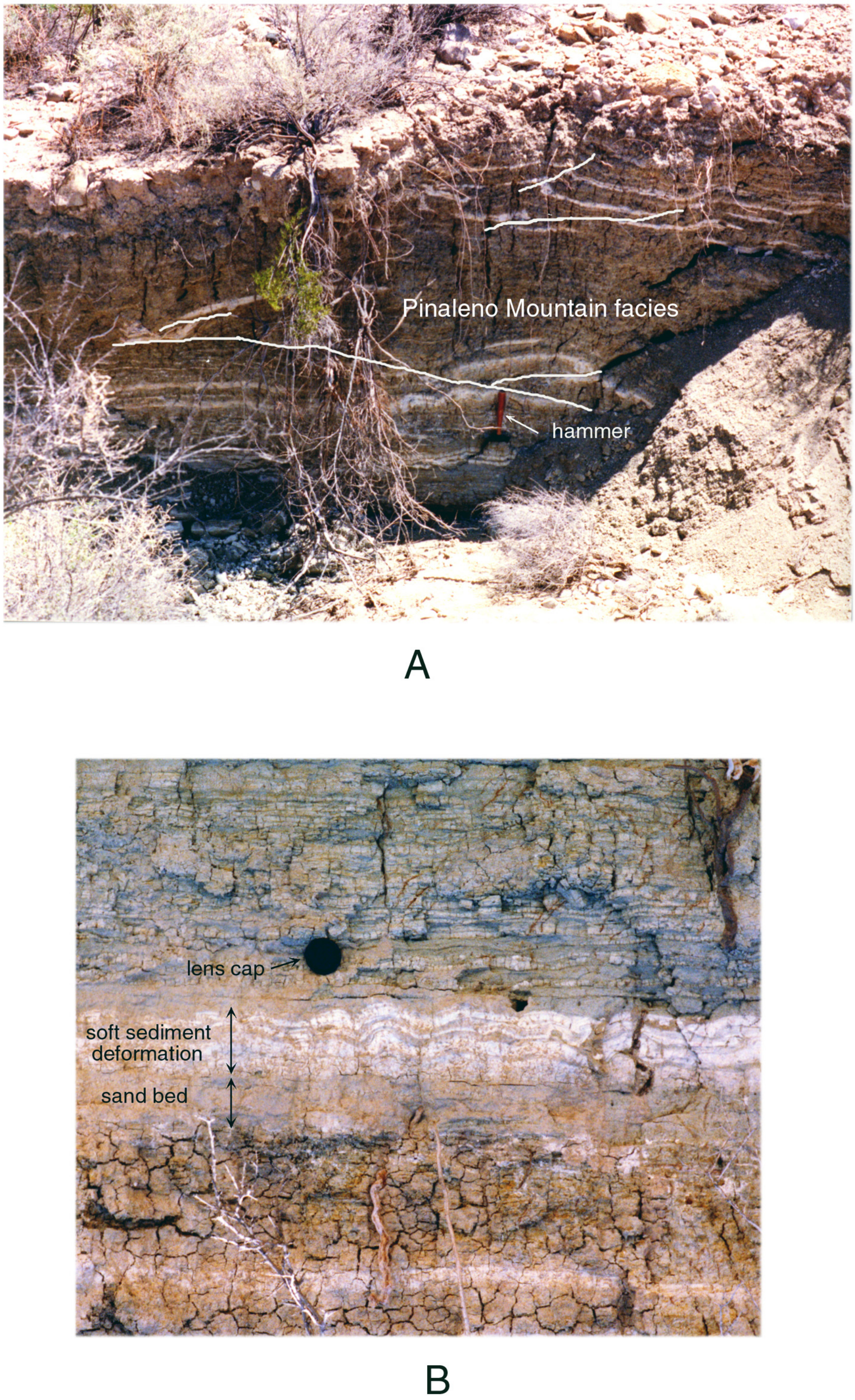


Figure 7. Photographs of slumping and soft-sediment deformation in Pinaleno Mountain facies (111 Ranch Formation) that may be related to earthquake shaking (Stop 1-3). A, White lines on photograph indicate low-angle slip surfaces and bedding planes along which displacement occurred. B, Small-scale-deformation in limy beds related to differential loading or liquefaction.

STOP 1-4. Pliocene and Pleistocene alluvial fans of Frye Mesa (Brenda B. Houser)

The purpose of this stop is to observe subtle upsection changes in size, sorting, and other characteristics of the proximal alluvial-fan facies sediments that comprise Frye Mesa and to consider the possible significance of these changes. We will walk 2.6 km (335 m of relief) up a washed-out dirt road on the eroded north face of the mesa to the Pleistocene piedmont-capping alluvium at the top.

Melton (1965) described the coarse-grained sediments of Frye Mesa as stream-laid cobble and boulder gravel having little evidence of mudflow deposition, and noted that the amount of sorting decreases and clast size increases upsection. He correlated finer-grained sediments at the base of the fan with basin-fill sediments dated as Blancan and Irvingtonian by Lance (1960). From this Melton concluded that the fine-grained beds at the base of the fan were deposited during Yarmouth interglacial time in a semi-arid climate, that the bulk of the fan was deposited diring the Illinoian glacial period in a cold wet climate, that the red soil cap was developed during the Sangamon interglacial in a warm humid climate, and that the discontinuous layer of very coarse alluvium at the top was deposited during the rigorous Wisconsin glacial climate. As we walk up the road we will see that, in general, Melton's description of the Frye Mesa fan is correct, but I doubt that the depositional history of the fan can be subdivided neatly into Pleistocene glacial and interglacial time packages. Rather, I think the variations observed in the alluvial-fan sediments can be correlated with climate change that occurred at the Pliocene-Pleistocene boundary.

The gradational change in the fan deposits, from somewhat better sorted and relatively finer-grained sediments below to unsorted and dominantly bouldery sediments above, is centered at about 1,160 m but spans the elevation interval of 1,145-1,175 km. There also is a subtle color change from grayish below to brownish above. The relatively fine grain size and moderate sorting typical of the lower fan deposits are demonstrated in figures 8a and 8b. Figure 8a shows a lenticular muddy sandstone bed about 30 cm thick overlying a bed of small boulders, cobbles, and pebbles in a muddy matrix. Figure 8b demonstrates sorting of larger size clasts into a bed one boulder thick, containing boulders as much as 1.0 m across, sandwiched between beds of smaller boulders. The bed of large boulders may have been transported as a thin debris flow.

Figures 9a and 9b show the very coarse grain size and poor sorting typical of the upper fan deposits of Frye Mesa. The three large boulders in figure 9a are each more than 3.0 m across. The exposure in figure 9b is interpreted to be a mudflow deposit because most of the clasts are matrix supported. Many other exposures, however, are typical of debris-flow deposits with an appreciable fluvial component as indicated by their chiefly clast supported framework. Note the deep weathering evidenced by granite clasts that are broken in half on the face of the exposure in figure 9b.∂

I agree with Melton's (1965) correlation of the lower finer-grained fan deposits with basin-fill sediments, however, the youngest basin-fill deposits of the Safford Basin are now known to be Blancan (late Pliocene) in age (Galusha and others, 1984) and ash-fall tuffs near the 111 Ranch fossil locality at Dry Mountain (fig. 1) were dated by fission tracks as no younger than 2.3 Ma (Dickson and Izett, 1981). Using trace and major element geochemistry, I correlated the Dry Mountain ash-fall tuffs with ash-fall tuffs interbedded in basin-fill deposits in the Freeman Wash area (Houser, unpublished data). Thus, on the north face of Frye Mesa, the lower 100 m of proximal alluvial-fan deposits (about 1,060 m to about 1,160 m elevation) probably are uppermost Pliocene and the upper 140 m (about 1,160 m to 1,295 m elevation) probably are lower to middle Pleistocene. The smooth surface of Frye Mesa and other range-front alluvial fans to the south along the northeast face of the Pinalenos, in conjunction with their high elevation, indicate that the fans were deposited no later than middle Pleistocene.

The most likely cause of the larger clast size and lack of sorting in the upper fan deposits compared to the lower deposits is the climate change at the Pliocene-Pleistocene boundary from warm to colder. Regardless of whether there was a change in the moisture regime, colder temperatures in the Pinaleno Mountains during Pleistocene glacial stages likely would lead to more freeze-thaw cycles and more snow pack and, hence, more mechanical weathering of the

A

B

Figure 8. Photographs showing typical sorting and grain size in lower fan deposits of Frye Mesa (Stop 1-4). A, Exposure of relatively fine-grained lenticular muddy sandstone bed about 30 cm thick overlying a bouldery gravel bed. B, Exposure of a one-boulder-thick debris flow (?) bed between beds of smaller boulders.

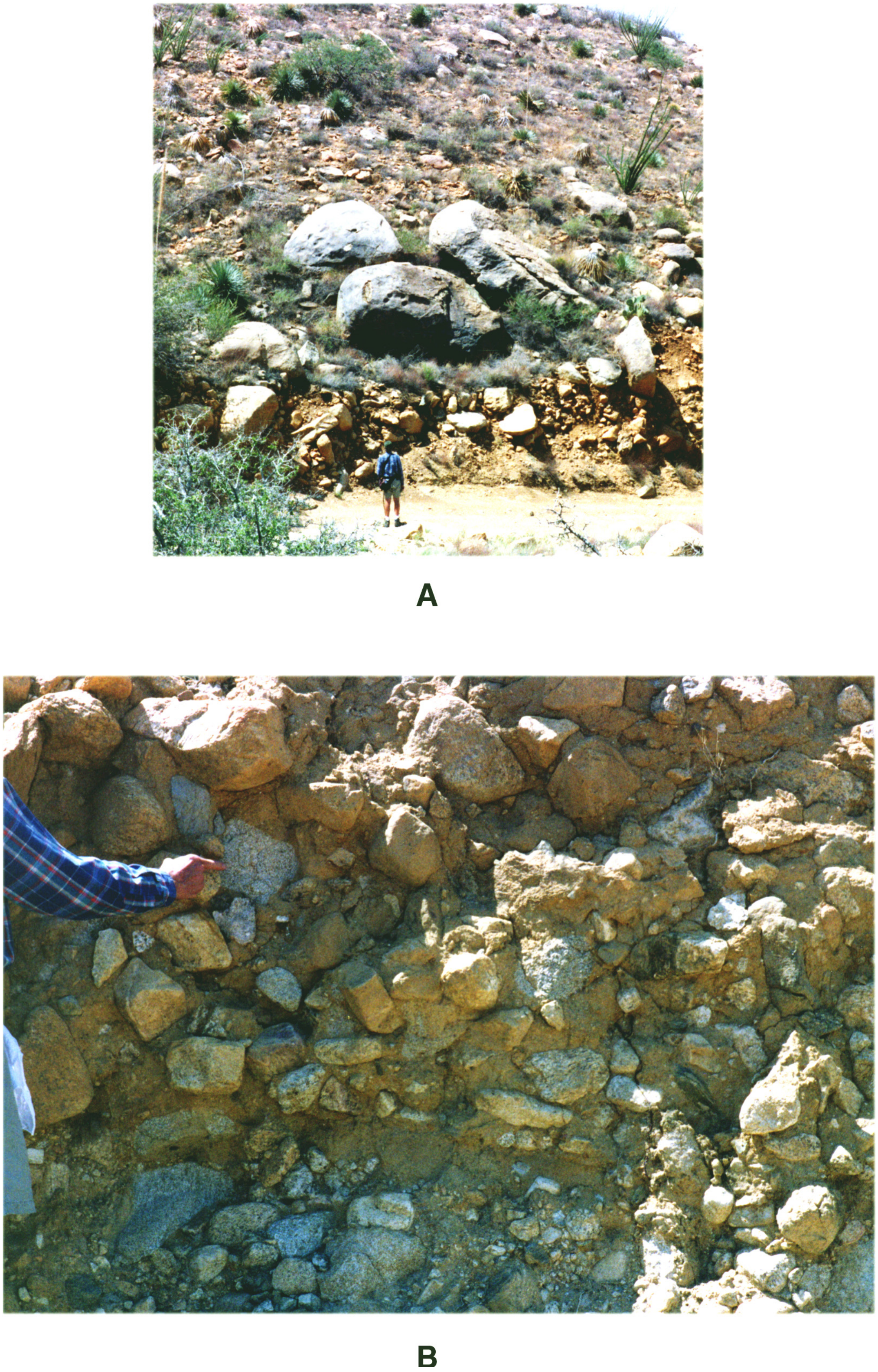


Figure 9. Photographs showing the large clast size and poor sorting typical of the upper fan deposits of Frye Mesa (Stop 1-4). A, Three boulders, each more than 3 m across. B, Exposure of a mudflow deposit showing that most clasts are matrix supported. Note the weathered granite clasts broken in half on the face of the exposure.

rocks and more discharge in streams. Early Pleistocene interglacial stages with climate similar to the Holocene may have resulted in erosion of some of the previously deposited fan sediments. Holocene erosion at the head of the Frye Mesa fan shows that the alluvial-fan sediments there were deposited in a deep pre-existing bedrock canyon.

A second factor to influence deposition of the Frye Mesa fan was the decrease in tectonic activity that occurred in many of the basins of southeastern Arizona at about the Pliocene-Pleistocene boundary. At this time, the rate of subsidence of the Safford Basin apparently decreased, through-flowing drainage by the Gila and San Simon Rivers was established soon afterward, and erosion of basin-fill sediments began. The gravity anomaly data, shown schematically in figure 1 indicate that, like the 111 Ranch subbasin, the Bear Springs subbasin is a half graben with its deepest side next to the Pinaleno Mountains (Wynn, 1981). The sedimentary record of the basin-fill and piedmont sediments shows that the alluvial fans along the Pinaleno Mountains filled in the subbasins and prograded across the southwestern side of the Safford Basin as the rate of down-to-the-northeast displacement on the Pinaleno range-front faults decreased at the end of the Pliocene. At about the same time, the amount of debris shed off the Pinaleno Mountains likely increased with the onset of the more rigorous Pleistocene climate, and the early Pleistocene Gila River started to erode both the basin fill and the distal ends of the prograding alluvial fans. Continual lowering of base level by the Gila River caused the first-formed alluvial fans to be abandoned and new thinner fans to be deposited on the piedmont surface.

Return to vehicles at the bottom of the hill.

52.2 Drive back down Frye Mesa Road to a dirt road leading to a windmill on right and turn southeast (right).

52.5 Park at corral and walk downstream about 0.1 mi to cut bank exposure on southeast side of Spring Canyon.

STOP 1-5. Pliocene Bear Springs basin-fill deposits and Pleistocene piedmont alluvium (Brenda B. Houser)

The outcrop at this stop in Spring Canyon illustrates the rapid basinward fining of the Pliocene Bear Springs basin-fill sediments and the less rapid fining of the overlying Pleistocene piedmont alluvium (fig. 10). In addition there are several normal faults that offset the Bear Springs deposits less than 1.0 m, down to the southwest, but probably do not offset the piedmont alluvium. The attitudes of the faults are N10^o-25^{o}W, 50^o-65^{o}SW.

The Bear Springs deposits grade from the proximal alluvial-fan facies of the bottom part of Frye Mesa to distal alluvial-fan or playa facies at this exposure within 1.6 km of the base of the mesa. This rapid facies change is characteristic of Pliocene basin-fill deposition along the southwest margin of the Bear Springs and 111 Ranch subbasins and is a result of the half graben shape of the subbasins, where the deepest parts of the subbasins were adjacent to the Pinaleno Mountains. Sediments from the northeast side of the basin were transported southwestward as much as 20 to 30 km; sediments derived from the Pinaleno Mountains on the southwest side of the basin were transported northeastward 5 km or less. During the late Tertiary, subsidence of the subbasins was apparently rapid enough to keep up with deposition of abundant coarse-grained detritus from the Pinalenos.

In contrast, the facies of the overlying middle Pleistocene piedmont alluvium grades from proximal alluvial fan to proximal/medial alluvial fan in the same distance suggesting that subsidence of the subbasin has been slower during the Pleistocene and coarse-grained sediments were carrried farther basinward.

The section here at Spring Canyon consists of (from top to bottom):

Pleistocene

4.5 m piedmont alluvium; fluvial (proximal to medial alluvial fan), poorly sorted, poorly bedded, size range is mud to small boulders, angular to rounded, pedogenic iron oxide developed throughout unit.

Pliocene Bear Springs basin-fill deposits (distal alluvial fan to playa)

1.5 m muddy sandstone; fluvial (flood plain, swampy?), greenish gray, fairly well bedded, micaceous, feldspathic, weak soil horizons.

1.0 m mudstone; fluvial (flood plain) or playa, pale red, thin bedded to laminated.

0.6 m muddy sandstone; fluvial (flood plain), greenish gray, massive, micaceous, feldspathic.

1.0 m mudstone; fluvial (flood plain) or playa, as above, top is channeled by overlying sandstone.

0.6 m mudstone; fluvial (flood plain, overbank), greenish gray, 2.0-cm-thick beds and nodules of white calcareous mudstone.

4.5 m muddy sandstone; fluvial (flood plain), greenish gray, pebble lenses, thick to thin bedded, micaceous, feldspathic, no paleosols

13.7 m Total thickness to creek bed

58.7 Return to U.S. 70 and turn east (right) on U.S. 70.

61.5 Junction U.S. 70 and 14th Ave. Turn south (right) on 14th Ave.

61.7 BLM Safford office. End of Day-one road log.

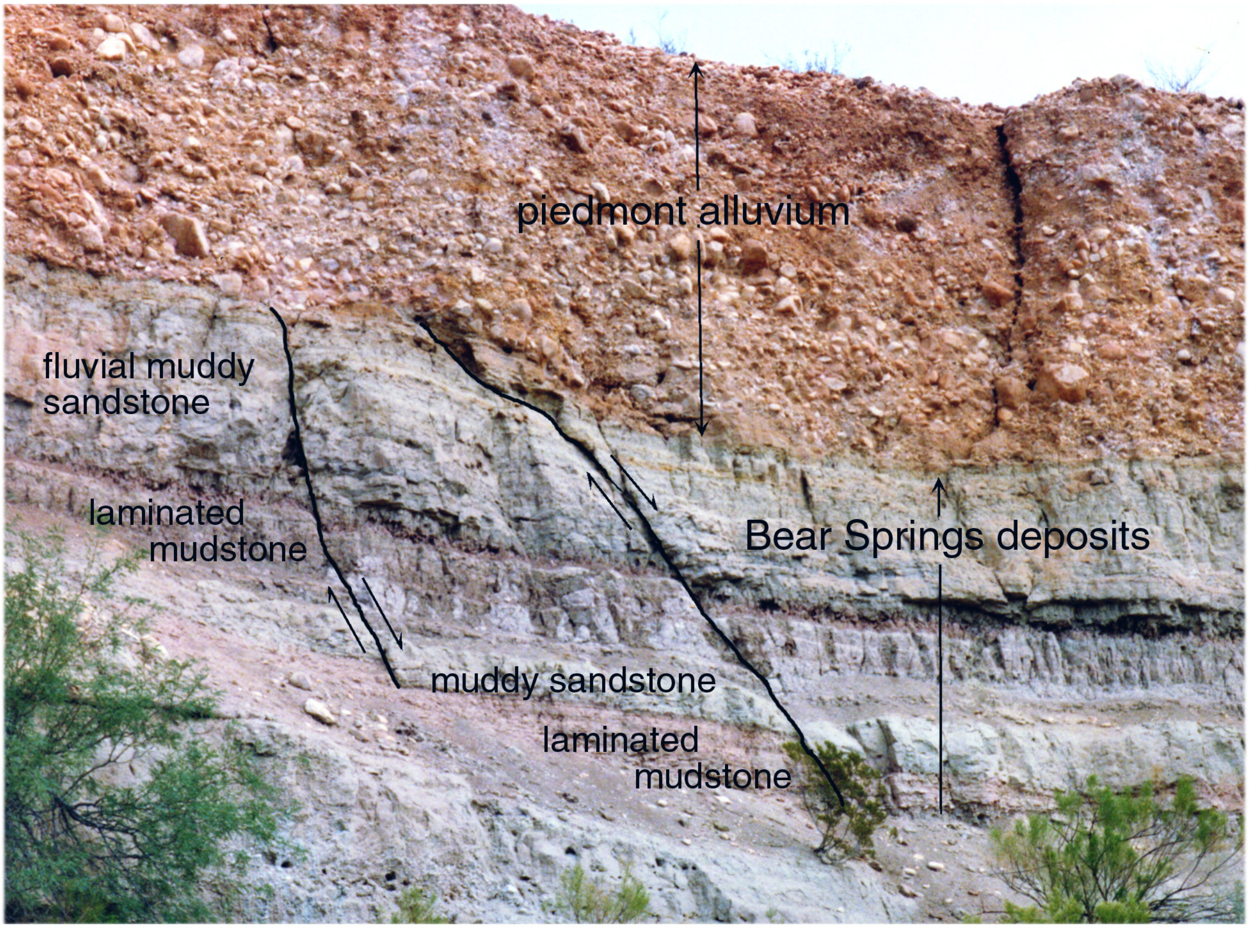


Figure 10. Photograph showing contrast between coarse-grained Pleistocene piedmont alluvium and underlying fine-grained Pliocene Bear Springs deposits (Stop 1-5). Both units are fluvial and were deposited the same distance from the Pinaleno Mountains range front.

SECOND-DAY ROAD LOG, OCTOBER 12, 2002

Geology of the northeast side of the Safford Valley, Gila Mountains piedmont, Bear Springs subbasin

Mi	Description
0.0	Depart from BLM parking lot located on the northeast corner of 14th Ave and 8th St. Go north on 14th Ave 0.2 mi to U.S. 70.
0.2	Junction 14th Ave. and U.S. 70. Turn west (left) on U.S. 70.
21.1	Turn north (right) in Fort Thomas (just east of the small park and Melvin Jones Memorial) on the road that crosses the Gila River.
22.3	T-junction with graded road that parallels the Gila on the northeast side of the river. Turn northwest (left).
23.8	From this point to about mi 24.8, a line of springs and seeps along the northeast side of the road is associated with a zone of east-, northeast-, and northwest-trending faults, which displace Gila River terrace alluvium. Apparent displacement is less than 10 m down to the southwest.
25.8	Normal fault in bank on northeast side of road (N65°W, 70°SW). Displaces Gila River terrace gravel at least 6 m relative to basin fill, down on the southwest. 15-cm-thick gouge zone contains rotated clasts.
26.0	Park at the mouth of the second steep-sided canyon on the right side of the road and walk up the canyon about 0.1 mi.

STOP 2-1. Faulted anticline in Pliocene basin-fill deposits and normal faults in Pleistocene Gila River terrace alluvium and piedmont alluvium (Brenda B. Houser)

The stratigraphy at this stop consists of Pliocene shallow lacustrine calcareous mudstone and interbedded algal mat limestone overlain by Pleistocene Gila River terrace gravel and piedmont alluvium. The Pliocene mudstone and limestone has been folded into a tight faulted anticline with a minimum amplitude of 15 m (fig. 11). This structure trends N30°W and can be traced along strike for 1.5 km with no change in shape. The crest of the anticline has been truncated by erosion and overlain in angular unconformity by Gila River terrace alluvium. Upstream in the canyon (northeast), three normal faults bound rotated horst and graben blocks consisting of mudstone and limestone overlain by Gila River terrace alluvium. The grabens are filled with locally derived fluvial sand and gravel, similar to piedmont alluvium but finer grained. The interfluves are capped with piedmont alluvium.

The anticlinal structure seen at this stop is highly unusual in rocks of this age in the southern Basin and Range, which lies in a regional extensional stress field. There are numerous normal faults in the area suggesting the structure may have formed as a result of local compressive stresses in the hanging-wall block during normal faulting as described by Brumbaugh (1984).

The exposed Pliocene basin fill is 2-3 Ma older here at the northern end of the Bear Springs subbasin than the basin fill in the 111 Ranch subbasin, and different species of ostracodes are present. Hornblende in a pumiceous ash-fall tuff about 1 m thick, interbedded with Pliocene mudstone 5.6 km northwest of Stop 2-1 gave an $^{40}Ar/^{39}Ar$ age of 5.02 Ma (Wrucke and others, in press). Evidence from ostracodes suggests that the calcareous mudstone and algal mat limestone were deposited in a shallow, fresh to slightly saline lake with seasonally cold water (R.M. Forester, U.S. Geological Survey, written commun., 1986). This latter interpretation is interesting in that a sample found near here from a thin limestone bed has ice crystal molds on its surface.

Return to vehicles.

29.7 Retrace route to T-intersection with Fort Thomas bridge road . Continue southeast on graded road along northeast side of Gila River.

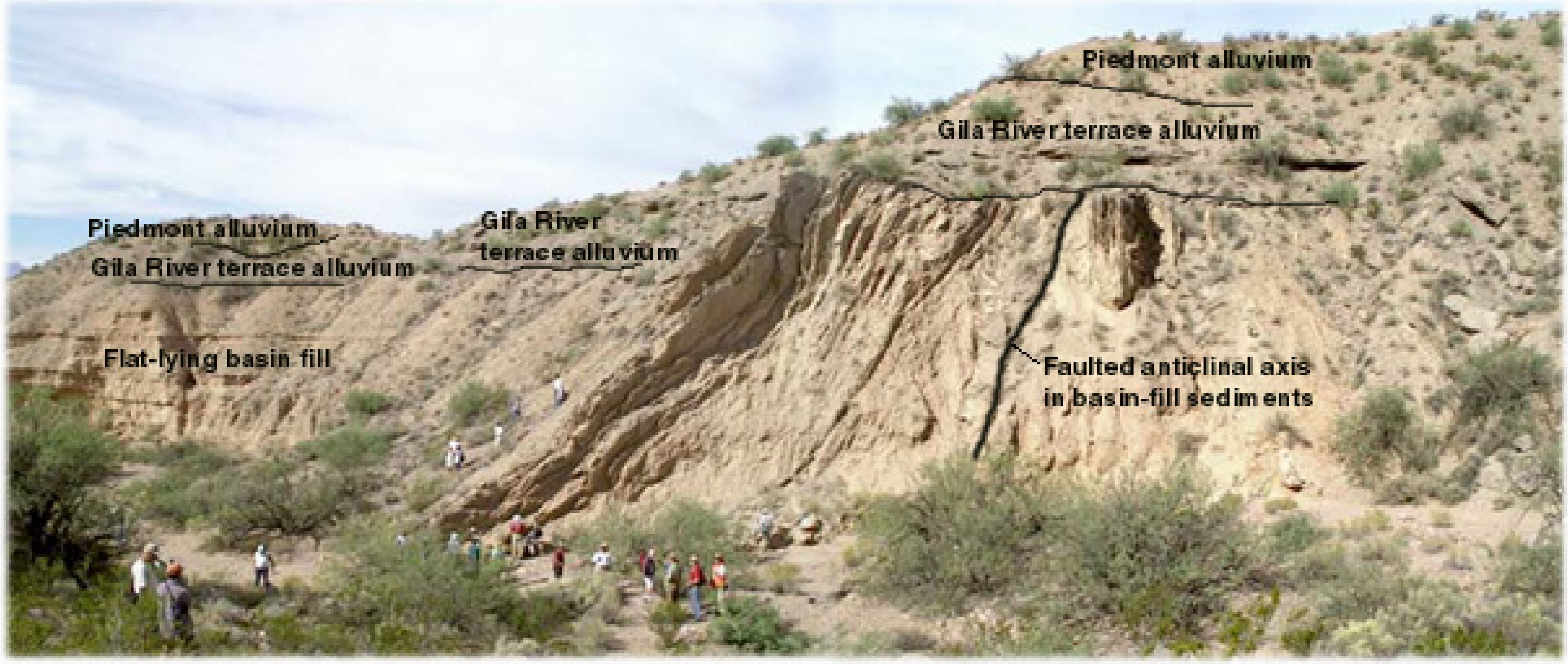


Figure 11. Photograph of tightly folded and faulted Pliocene basin-fill sediment overlain in erosional unconformity by undeformed Pleistocene alluvium (Stop 2-1). Downstream to the left all the units are undeformed. Photograph by Arlene Tugel.

32.2 Mouth of George Canyon. Turn northeast (left) and drive up the wash.

33.6 Park at exposure on west side of George Canyon.

STOP 2-2. Pleistocene Gila River terrace alluvium, loess, and piedmont alluvium (Brenda B. Houser)

The purpose of this stop is to examine an exposure of the loess bed that is present nearly everywhere on the northeast side of the Gila River between 0.64 Ma Gila River terrace alluvium (see Stop 2-5) and piedmont alluvium. At this locality it is about 3 m thick, underlain by Gila River terrace alluvium, and overlain by about 3 m of peidmont alluvium (fig. 12). It is composed of light colored, very pale orange to yellowish gray, slightly sandy silt. Typical exposures show both massive unbedded horizons as much as 50 cm thick and well bedded horizons with bedding 2-20 cm thick. It appears to be reworked in part and commonly has mottled, iron-stained paleosol horizons containing calcareous root casts. The base of the sandy silt is conformable with the underlying Gila River terrace alluvium. In places it appears to fill broad channels in the surface of the terrace alluvium (fig. 13a). Locally the upper surface of the loess shows channels and potholes that were eroded by streams carrying the overlying piedmont alluvium (fig. 13b). The reworked appearance, paleosol horizons, and eroded upper surfaces all suggest that a considerable amount of time lapsed between deposition and reworking of the loess and the time when it finally was covered by piedmont alluvium.

The source of the silt in the loess deposit was probably the Gila River flood plain and the broad alluvial plains southwest of the river at the mouths of the streams draining the Pinaleno Mountains. The prevailing southwest winds picked up the silt from these sources and deposited on the northeast side of the river. The loess bed seems to be unique to this part of the Safford Basin and to this part of the stratigraphic section, and as such, it may be the record of a unique set of conditions that occurred in middle to late Pleistocene time in the Safford Basin. Was it deposited on the Pleistocene Gila River flood plain following an abrupt shift in the river channel? Was the loess deposition triggered by climate change? Additional detailed mapping is needed to

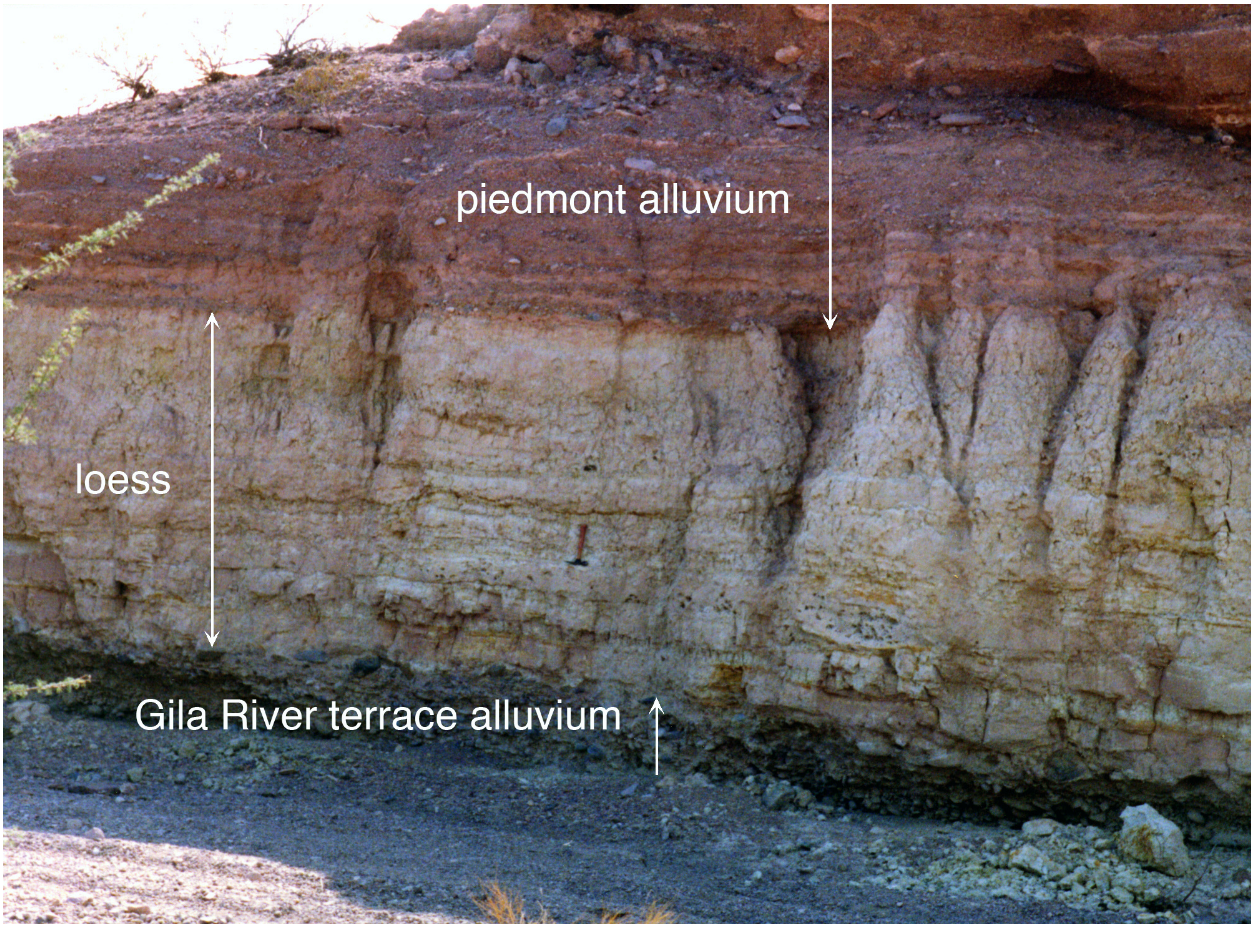


Figure 12. Photograph showing 3-m-thick reworked loess bed between Piedmont alluvium and Gila River terrace alluvium (Stop 2-2).

Figure 13. Photographs of the loess beds at other sites. A, Loess bed filling a broad channel on the surface of the Gila River terrace alluvium. B, Loess bed with a channeled upper surface eroded by streams carrying the overlying piedmont alluvium.

answer these and other questions regarding the loess bed.

Return to vehicles.

38.7 Retrace route to U.S. 70 in Fort Thomas and turn southeast (left) on U.S. 70

51.8 Junction U.S. 70 and Main St. in Pima. Turn north (left) on Main St.

53.1 Cross Gila River.

54.0 Turn east (right) on obscure dirt road near some houses. Drive past and around rocky fields, over an irrigation ditch, and up Peck wash.

54.5 Exposure on the right at the mouth of Peck Wash shows well-bedded pale red mudstone (Pliocene basin fill) overlain by Pleistocene Gila River terrace alluvium overlain by Piedmont alluvium.

7.7 Park next to an exposure of complexly faulted and slumped Pliocene mudstone and Gila River terrace alluvium on the left.

STOP 2-3. Soil study of rock-bordered grids agricultural site (Jeffery A. Homburg)**; faulted Pliocene basin fill and Pleistocene Gila River terrace alluvium** (Brenda B. Houser)

Climb up the bank on the west side of Peck Wash and walk over to a soil test pit.

Gridded field complex. Soil properties associated with a Classic Period (~AD 1,150-1,450) agricultural complex were invesitgated to document and evaluate soil fertility and productivity of soils in both cultivated and uncultivated settings. The fields consist chiefly of rock features arranged in elaborate waffle-like grid patterns, rock piles, and agicultural terraces, with fields spread over a 2.4- by 1.6-km area (fig. 14). The complex was built on the Pleistocene Gila River terrace, above the river flood plain. There are advantages to farming on elevated landforms including avoiding or minimizing the effects of killing frosts caused by cold air drainage. Because of great variability in the length of the growing season and unpredictable floods, combined with highly unpredictable precipitation patterns both spatially and temporally, ancient farmers commonly spread their fields over different soils and landforms as a buffering strategy to ensure adequate food supplies. Previous soil studies have found that ancient farming systems can degrade or enhance the nutrient status of agricultural soils. The goal of this study was to assess the effects of cultivation on soil productivity.

For discussion of location of samples, methods, and results, see the paper by Homburg and Sandor, this volume. Briefly, there was no indication that ancient farming activity at this locality seriously degraded the soil. An especially puzzling and elusive aspect of this study is determining what crops were, or might have been, cultivated. Overall, soil nutrient levels in the Safford gridded field complex are sufficient to have supported maize agriculture, but the thin soils, high temperatures, low rainfall, and low runoff throughout most landscape positions of the field area suggest that crops such as agave or other drought-tolerant plants were likely the focus of agricultural production.

Return to the exposure on the west side of Peck Wash next to the vehicles.

Faulted basin fill and Gila River terrace alluvium The faulting at this stop is complex and, like Freeman Wash (Stop 1-3), the exposure varies from year to year depending on erosion. The Pliocene basin fill here near the southeastern end of the Bear Springs subbasin consists of pale brown fluvial and shallow lacustrine calcareous mudstone and sandstone, probably a distal alluvial-fan facies in large part. The basin fill is overlain by Gila River terrace gravel, which is in turn overlain by 6 m of loess and overbank deposits. Piedmont alluvium is present above the loess. In 1990 the exposure showed a zone of faulting 30 m long, in which the base of the Gila River terrace alluvium was dropped about 12 m in a series of two or three steps, down to the southwest. The largest fault strikes about N45°W and is vertical (fig. 15).

Several pothole-like features filled with unbedded terrace gravel are exposed at the top of the basin fill. These features are cross sections of gravel-filled erosion pipes. The basin fill along steep banks in this area seems to be prone to erosion by piping.

Figure 14. Photographs of rock-bordered fields north of Pima, Arizona taken from an ultralight aircraft. Photographs are courtesy of William E. Doolittle.

Return to vehicles and continue north on graded road.

55.0 Mud Spring reverse fault exposed in road cut on right (fig. 16). Fault is in Pliocene calcareous sandy mudstone. Gouge zone is about 30 cm wide and is filled with rotated clasts from the overlying Gila River terrace alluvium.

5.4 Turn right on dirt road.

55.5 Park at corral. There are lots of nails on the ground here. Walk eastward on dirt track about 0.2 mi, across two washes, to area of rock grids.

STOP 2-4. Geologic setting of rock-bordered grids agricultural site (Brenda B. Houser)

The stratigraphy at the agricultural site is the same as we have seen earlier today; Pliocene calcareous mudstone and muddy sandstone, and Pleistocene Gila River terrace alluvium, loess, and piedmont alluvium. Figure 17 is a geologic sketch map showing the trace of three faults and the distribution of some of these stratigraphic units in relation to the location of rock-bordered grids in the eastern half of the site. The faults have an obvious control on the location of the grids, which is in part topographic. Some of the scarps associated with the faults were apparently too steep for the grids to serve their agricultural purpose and therefore, were avoided.

A second factor which controlled the location of the grids is the lithology of the surficial materials. As we saw at our other stops this morning, Gila River terrace alluvium nearly always was covered with a layer of coarse-grained piedmont alluvium. An exception is shown in figure 17 where a triangular area of Gila River terrace alluvium (Qgra) crops out on the north side of the Mud Spring and Big Spring Faults. Rock-bordered grids are conspicuously absent from this area and, as we walk across it, the reason for their absence is clear. There are very few medium to large boulders in the Gila River terrace alluvium and the few that are there are rounded. Thus there are no good grid-building rocks in the Gila River alluvium. Angular andesite boulders, which are common in the piedmont alluvium, were the preferred building material for the grid walls.

The soil may also be a factor in that, the soil derived from Gila River terrace alluvium tends to be loose and sandy, and different forbes grow in it than in piedmont alluvium. The soil may not retain moisture as well as the more clayey soil derived from piedmont alluvium

Gridded agricultural sites are not everywhere present in the Gila Valley nor are they randomly distributed. There are no gridded agricultural sites southeast of the area shown in figure 17. Between the area of figure 17 and the Gila Box where the Gila River enters the Safford Basin (fig. 1), the Gila River terrace alluvium lacks a covering of piedmont alluvium (Houser and others, 1985), perhaps because there is not as much Tertiary andesite available there on the southwest side of the Gila Mountains. Whatever the reason for the restricted piedmont alluvial cover, it is interesting that there also are no more rock-bordered grids to the southeast, presumably because there are few suitable rocks to build the grids.

Return to the vehicles, either along the road we walked in on or by way of Big Spring Wash where the Big Spring Fault is poorly exposed.

57.0 Retrace route out to the paved road. Turn south (left) on paved road.
57.3 Turn east (left) on paved road.
65.8 Turn north (left) on paved road to land fill.
66.1 Park on right at gate to land fill and walk to outcrop on other side of road.

STOP 2-5. Lava Creek B ash in Gila River terrace alluvium (Brenda B. Houser)

The ash exposed here was indentifed as the ~0.64 Ma Lava Creek B ash (Lanphere and others, 2002) by Glen Izett (U.S. Geological Survey retired, oral commun., 1985). The identification was based on trace and major element geochemistry and on the appearance of the zircon crystals. The ash bed is about 30 cm thick and is interbedded with sandy and gravely Gila River terrace alluvium at an elevation of about 902 m, 24 m above the elevation of the Gila River. The ash is present at several places on this side of the river but commonly is obscured by material washing down from above.

Figure 14. Photographs of gridded rock features north of Pima, Arizona taken from an ultralight aircraft. Photo is courtesy of William E. Doolittle.

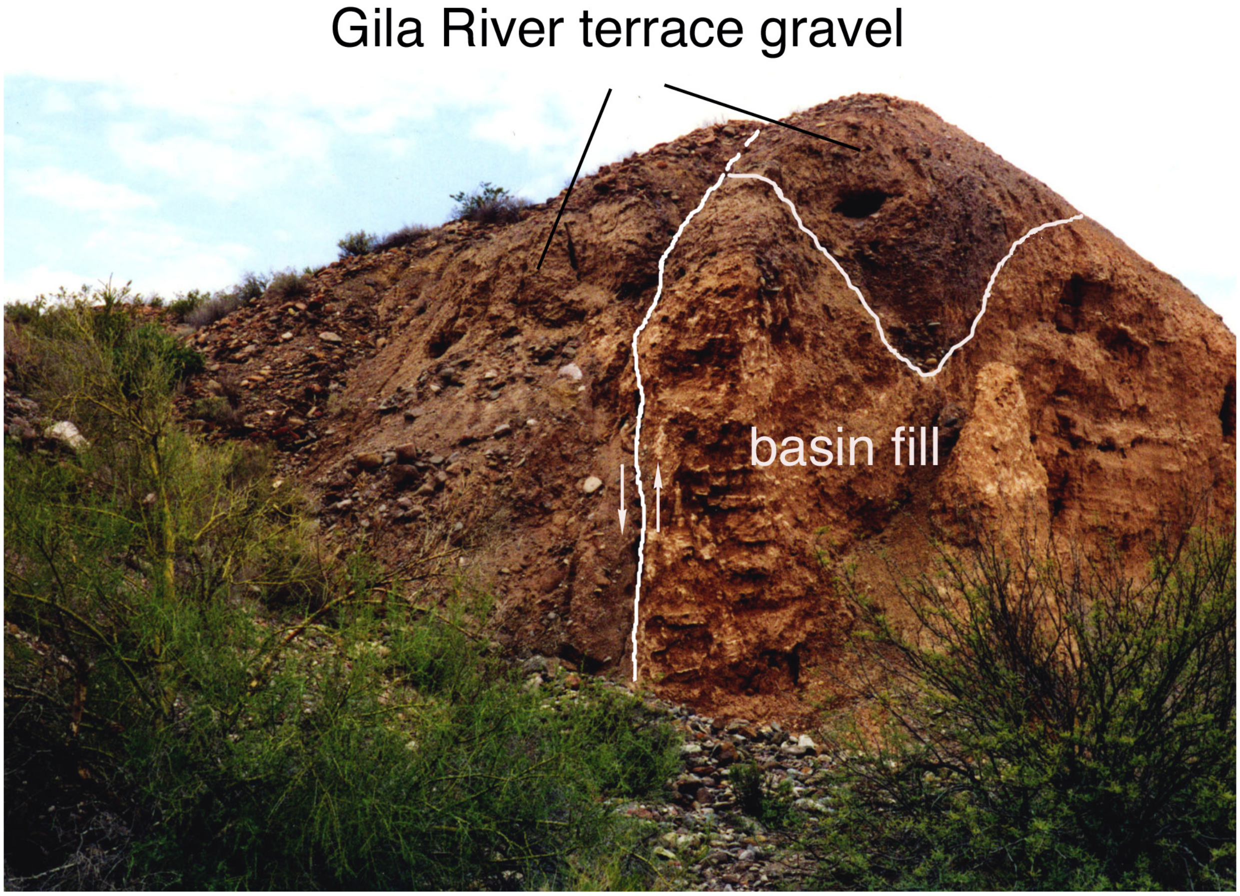


Figure 15. otograph of normal fault displacing Gila River terrace gravel down on the southwest.

Figure 15. Photograph of normal fault displacing Gila River terrace alluvium down on the southwest (Stop 2-3). Terrace gravel on the right side of the fault is filling an erosion pipethat developed in the basin fill beneath the terrace.

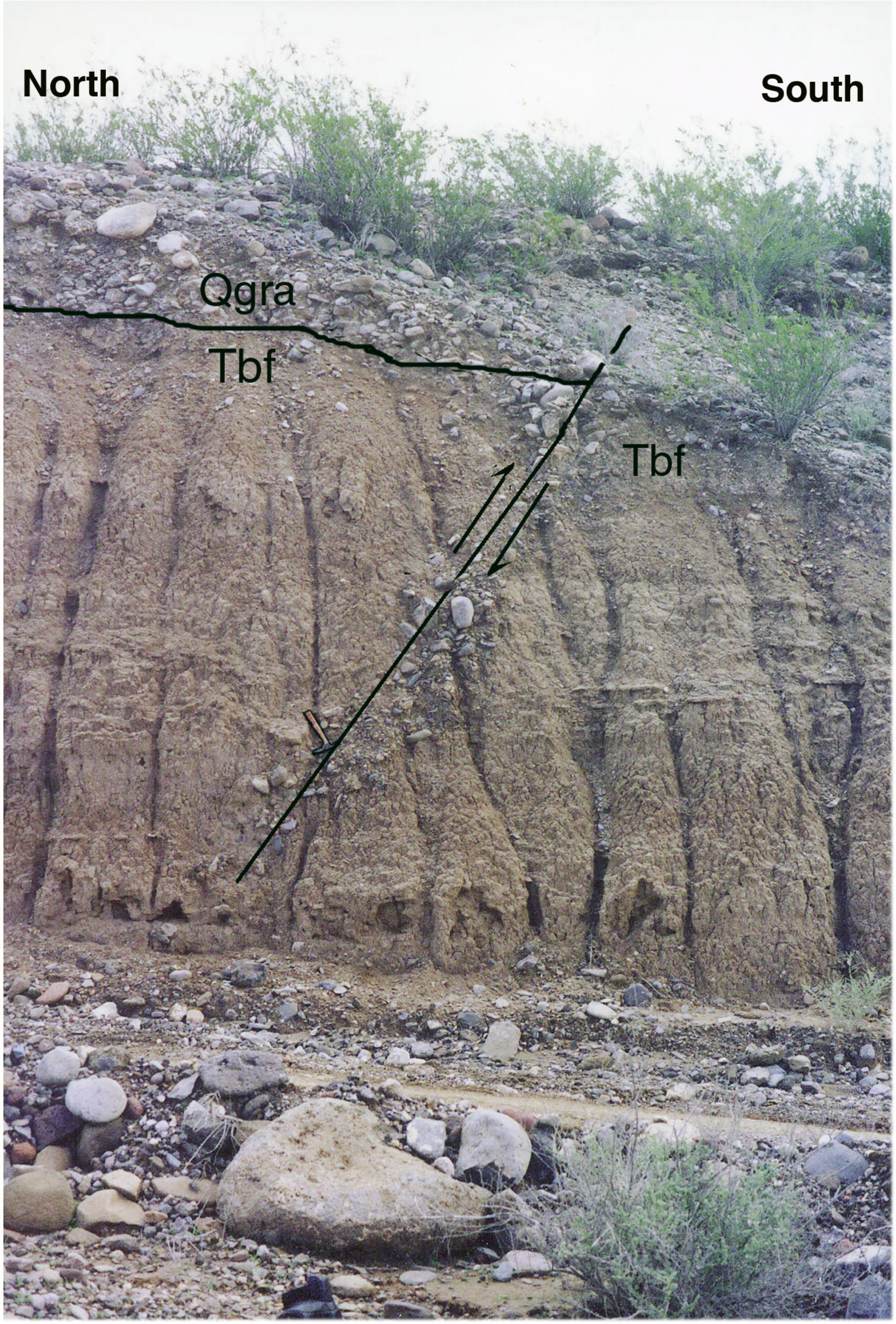


Figure 16. Photograph of the Mud Spring reverse Fault offsetting Pliocene calcareous mudstone (Tbf) and Pleistocene Gila River terrace alluvium (Qgra). Gouge zone is filled with clasts of terrace alluvium, many of which have been rotated. Quaternary offset on the Mud Spring Fault is about 10 m. Exposure is along the road on the east side of Peck Wash (fig. 17) between Stops 2-3 and 2-4.

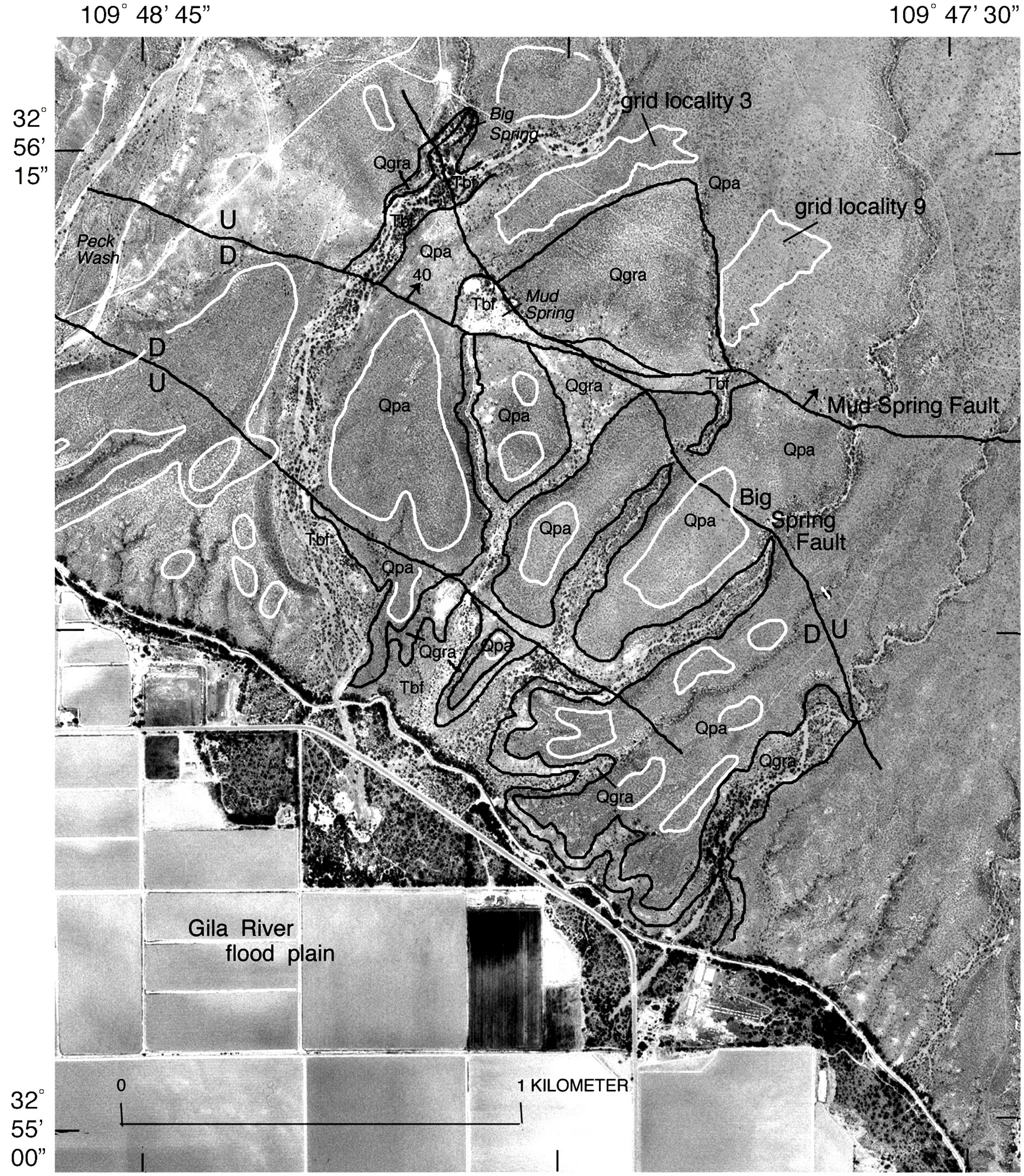


Figure 17. Geologic sketch map of area of rock-bordered fields east of Peck Wash showing relationship of faults and surficial geologic materials to location of fields. White lines enclose areas of rock-bordered fields (D.R. Lightfoot, unpublished data); fields are absent outside these areas. Note that fault scarps were avoided as locations for rock-bordered fields, perhaps because the slopes are too streep. The triangular area underlain by Gila River terrace alluvium north of the intersection of the Mud Spring and Big Spring Faults (Stop 2-4) also was avoided because the terrace alluvium doesn't contain boulders large enough to construct rock borders. Tbf = Pliocene basin fill: Qgra = Pleistocene Gila River terrace alluvium: Qpa = Pleistocene piedmont alluvium.

The estimated rate of downcutting of the Gila River in the last .64 m.y. (middle Pleistocene to Holocene) can be calculated using the 24 m height of the Lava Creek B ash above the Gila River. The rate is about 4 cm/k.y. and is in good agreement with the downcutting rate of somewhat greater than 5 cm/k.y. calculated by Dethier (fig. 1, 2001) for the Gila River in the Duncan Basin.

An estimate of the late Pliocene through early Pleistocene (~2.0 m.y. to 0.64 m.y.) rate of downcutting for this part of the Gila River also can be calculated using the elevation of the Lava Creek B ash. The maximum elevation of the contact between the youngest basin fill and oldest Gila River alluvium in the Safford Basin is 1048 m (T. 6 S., R. 27 E., sec. 26; Houser and others, 1984) - 146 m above the Lava Creek B ash. This calculation yields a downcutting rate of about 11 cm/k.y. The greater rate of downcutting in the early history of the Gila Valley may reflect the speed with which basin-fill sediments were eroded as the river established its gradient following initiation of through-flowing drainage. Pleistocene climate changes also may have contributed to the rate of downcutting.

Return to vehicles and drive back down to intersection with paved road.

66.4 Turn east (left) on paved road.
66.9 Turn right (south) onto airport road at stop sign.
68.7 Cross Gila River and turn right (west) on U.S. 70 in Safford.
69.2 Turn left (south) on 14th Ave.
69.4 BLM Safford office. End of Day-two road log.

THIRD-DAY ROAD LOGS, OCTOBER 13, 2002

Two choices:

(1) Blancan vertebrate fossil site (Glyptodont), San Simon Valley

leader: Larry Thasher, Safford BLM

or

(2) Ancient agricultural systems and settlements in Lefthand Canyon, Safford Valley

leader: Jeff Homburg, Statistical Research, Inc.

Glyptodont site road log:

Mi.	Description
0.0	Depart from Bureau of Land Management (BLM) parking lot located on the northeast corner of 14th Ave. and 8th St. in Safford. Go east on 8th St. 1.0 mi to U.S. 191.
1.0	Turn south (right) on U.S. 191.
17.4	Turn east (left) on Tanque Road.
24.2	Park vehicles and walk south about 0.5 mi to *Glyptodont* site.

STOP 3-GLYPTODONT

A discussion of the Glyptodont site and other Blancan vertebrate sistes in the Safford/San Simon Valley is given in the paper by Thrasher (this volume).

Ancient agricultural site road log:

Mi	Description
0.0	Depart from BLM parking lot located on the northeast corner of 14th Ave and 8th St. Go north on 14th Ave 0.2 mi to U.S. 70.

0.2 Junction 14th Ave. and U.S. 70. Turn west (left) on U.S. 70.

7.8 Junction of U.S. 70 and Main St. in Pima. Turn south (left) on Main St.

9.3 Turn west (right)

10.3 Bear southwest (left) and drive southwest along the southeast side of Cottonwood Wash.

15.3 Turn south (left) on dirt road

18.3 Park vehicles

STOP 3-Ancient agricultural site

A discussion of the ancient agricultural site is given in the paper by Neely and Homburg (this volume).

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