Padelford Wash F.D.S. -- Inactive Fan Documentation

FCD 99-12

July 7, 2003

PADELFORD WASH FLOODPLAIN DELINEATION STUDY

"INACTIVE FAN" DOCUMENTATION

INTRODUCTION

The lower portion of the Padelford Wash FDS has some distributary flow paths, with six major flow paths at the downstream end of the study. Some types of distributary flows can be in an active state, that is, the flow paths and the related flow distributions can change over time. If a flow system is active, there can be uncertainty in projecting current conditions into the future. If a flow system is inactive, future flooding conditions will be very close to current conditions.

To determine the level of geomorphic activity of this portion of the study-stream-system, surficial geology data was collected, a field investigation was performed, and historical aerial photos were compared.

SURFICIAL GEOLOGY

During the course of the Padelford Wash Floodplain Delineation Study, the Flood Control District of Maricopa County (FCD) obtained a copy of a surficial geology report, that covers the study area, entitled:

> Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona, Arizona Geological Survey (AZGS), Open-File Report 94-21, October 1994
>
> (a copy of this report is included at the back of this packet)

The bottom-line conclusion from this report is that the soil surfaces between the flow splits of lower-Padelford Wash are mature, with weak to moderate desert pavement development.

A copy of the Surficial Geology Map, with color shading, is enclosed in the roll of large sheets. In the lower right portion of this map, the surface related to the streambeds of Padelford Wash is called "Ya2" and is shaded orange. The surface ages in the map key are from Table 2 of Page 6 of the AZGS report. The age estimate for the "Ya2" is less than 500 years. The overbank areas between the splits of lower-Padelford Wash are all surface "Ma2", which has an estimated age of 10,000 to 200,000 years.

To the west of the Padelford Wash area, there are overbank areas with a surface that has an "in-between age". This surface is called "Ya1", is shaded pink on the map, and has an estimated age of less than 10,000 years. Unlike this area to the west, the Padelford Wash stream-system has none of this in-between-aged surface. From this it can be concluded that the Padelford Wash stream-system is older and likely more stable than the area to the west.

All of the overbank areas of Padelford Wash are the 10,000 to 200,000 year-old "Ma2" surface. In the characterization of alluvial fans, the surface age of 10,000 years has been used as a guideline for separating active areas from inactive areas. In the Piedmont Flood Hazard Manual developed by FCD (see the next two sheets), the surface-parts of alluvial fans that are less than 10,000 years old are considered to be active.

In summary, the surficial geology report indicates that the overbank areas are mature and have not received any sediment deposition for at least 10,000 years.

An aerial photo (taken in 2002) of the Padelford Wash Floodplain Delineation area is included in this packet. The scale of this photo is 1 inch = 1000 feet, while the AZGS surficial geology map has a scale of approximately 1 inch = 2000 feet. To aid in the use of the photo and map, the top of a nearby hill is marked on both the photo and the map.

PIEDMONT FLOOD HAZARD ASSESSMENT FOR FLOOD PLAIN MANAGEMENT

for Maricopa County, Arizona

USER'S MANUAL

Draft of August 1998 by Hjalmarson

**Flood Control District
of Maricopa County
2801 West Durango Street
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Table 3.3. Steps for defining and characterizing alluvial fans.

CHARACTERISTIC	DATA SOURCE	FUNCTION (Define on topographic map)
<u>Type of fan?</u>		
Alluvial, debris flow, or composite?	Field work	Examine morphology, facies assemblages and other evidence of sedimentary processes
Ideal, composite, or segmented?	Topographic maps & field work	Make profiles along fan.
Incised/not incised?	same as above	Throughflow and local channels.
Drainage patterns	Topographic maps & aerial photos	Tributary, Distributary and/or Anastomizing?
<u>What parts of fan are active(< 10,000 years) and/or inactive? If practicable, use time scales less than 10,000 years.</u>		
Depth of incision	Topographic maps & fieldwork	(Depth of incision <2ft, about 3ft, 3 ft-10 ft, >10 ft)
Flow path movement	Aerial photographs	Rate of movement and proportion of channels.
Fan surface morphology	Topographic maps & field work	(Bar & channel, smooth, deeply dissected)
Desert pavement and desert varnish	Aerial photos & field work	(None, weak, moderate, strong development)
Soil characteristics	Soil maps and field work (trenching)	(B-horizon development and $CaCO_3$)
<u>Is the drainage basin typical of those found above active alluvial fans?</u>		
Sediment supply	Soils maps, aerial photos and field work	(Abundant, moderate or little medium to coarse grained sediment on steep basin slopes or along channel incised in relict fan)
Basin shape	Topographic map	(Rounded or elongated)
Drainage pattern	Topographic map and aerial photos	(Uniform or non-uniform length of first and second order channel segments)

GROUND PHOTOS

Ground photos are also included in this packet, and the locations for these are noted on the aerial photo. In Figures 1-A, 1-B, and 2, on Sheet 1 of 4 of the ground photos, two streambeds of the Padelford Wash flow splits are shown. These streambeds have uniform and smooth gravel surfaces, while the stream-banks are rounded with well developed vegetation, which indicates some degree of stability. Figures 3-A and 3-B show an overbank area between two of the flow splits. The black surfaces appear to be some sort of desert crust on the soil.

Figures 4 through 7, of Sheets 2 and 3 of 4, were taken further downstream, and exhibit streambed character and overbank character similar to those of the upstream photos.

The next group of ground photos, taken even farther downstream, are Figures 8 through 13, on Sheets 3 and 4 of 4. At these locations, the flow splits are farther apart, and the overbank areas are much larger. The panoramic view of Figure 11 shows that the flow splits are more incised than the upstream areas, but the same sort of smooth, uniform, gravelly streambeds occur, as well as the rounded stream-banks.

Figure 14 shows some well-developed desert pavement in a typical overbank area farther downstream. Desert pavement surfaces exhibit a concentration of pebbles and cobbles, due to the removal of the fine grained material by wind or sheet flow, and due to the lack of alluvial deposition by flooding events.

Field investigation revealed that the active areas are limited to the stream channels. This agrees with the surficial geology report. All of the stream channels are more-than-enveloped by the Regulatory Floodways and Administrative Floodways of the Floodplain Delineation Study, thus insuring that the public will be out of the uncertain-flood-hazard of the active areas.

Also, field examination of the overbank areas between the flow splits, revealed well-developed, local tributary-style drainage patterns. All indications lead to the conclusion that these overbank areas are, in general, stable and inactive.

AERIAL PHOTOS

Aerial photos of the study area from the years 1951 and 1958 were obtained. Figure 15 is a full size copy of the 1951 aerial photo, and Figure 16 is a full size copy of the 1958 aerial photo.

The same 1951 aerial photo was used to produce the letter-sized Figure 17. Figure 17 includes yellow Cadastral Section Lines and street names that were added to the image. For comparison, Figure 18 is a 2002 aerial with the same projection and Section Lines.

Inspection and comparison of the aerial photos from 1951, 1958, and 2002, showed that the streambeds of the Padelford Wash study area, remarkably, have not changed position or width. This streambed network has been very stable during the last 51 years.

CONCLUSIONS

The study of the Surficial Geology of this area by the Arizona Geological Survey determined that the overbank surfaces between the splits of Padelford Wash have ages of 10,000 to 200,000 years. Ground inspection of the area revealed: stable channel-forms, stable channel-bank-forms, and mature, stable, and inactive overbank areas. Historical comparison of aerial photos showed no change in the streambeds during the last 51 years.

All of these study approaches suggest stable conditions, for which the flow splits of Padelford Wash are not actively changing or migrating. With the FDS's Regulatory Floodway north of Dove Valley Road, the FDS's Administrative Floodways south of Dove Valley Road, and the related regulation of new housing development, provision has been made so that any potential man-caused disturbances to this inactive-stability of the flow split system, will be prevented. This will also keep future development out of the flood hazard of the active channels.

Beyond the Padelford Wash FDS, this area will receive some limited further study. An Area Drainage Master Study is currently underway for the watershed that includes Padelford Wash. This ADMS will include geomorphic surveys of the watershed.

FLOOD CONTROL DISTRICT
of
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July 7, 2003

Pernille Buch-Pedersen, Regional Manager
Michael Baker Jr. Inc.
3601 Eisenhower Avenue, Suite 600
Alexandria, Virginia 22304

Case No.: 03-09-0315P

Subject: Padelford Wash Floodplain Delineation Study

Transmitting Alluvial-Fan-Evaluation Documentation

Reference: Your letter of March 11, 2003, requesting more data, and

Sacha Tohme's email of June 10, 2003, granting a deadline extension

Dear Ms. Buch-Pedersen:

I have enclosed a letter-sized packet and a roll of large sheet exhibits. These items address the active/inactive condition of the distributary-flow area at the downstream end of the subject study, and include a Surficial Geology report, field photos, historical aerial photos, and explanatory text.

If you have any questions, please contact me at 602-506-4732, or mwd@mail.maricopa.gov.

Sincerely,

Mike Duncan

Mike Duncan, P.E., CFM
Flood Delineation Branch

Open-File REPORT

Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona

by
Gary Huckleberry

Open-File Report 94-21

PUBLISHED BY THE

ARIZONA GEOLOGICAL SURVEY

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Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona

by
Gary Huckleberry

Open-File Report 94-21

Arizona Geological Survey

October, 1994

This report is preliminary and has not been edited or reviewed for conformity with Arizona Geological Survey standards

INTRODUCTION

Most of southern and western Arizona lie within the Basin and Range physiographic province, a region characterized by broad valleys and linear mountain ranges. The valleys are deeply filled with alluvium that has eroded from adjacent mountains during the last 10 My[1]. This aggradation has been driven by tectonism and climate change, although regional tectonic stability within the last 5 My suggests that climate change is the more recent dominant driving force (Morrison, 1985). Climatic fluctuations between relatively wet and dry conditions have resulted in pulses of aggradation producing a mosaic of different aged alluvial deposits in piedmont areas. Urban development on piedmonts, especially in the Phoenix Basin, has created a need to better understand the distribution and nature of these deposits. Surficial geologic maps characterize and distinguish different piedmont deposits on the basis of age and genesis. Such information provides baseline data for evaluating geologic hazards potential (e.g., Pearthree, 1991), locating possible source areas for industrial minerals (e.g., Wellendorf et al., 1986), and determining locations favorable for groundwater recharge (e.g., Huckleberry, 1994). Moreover, these maps are also useful for assessing the potential for buried cultural resources and providing insight into local geologic history and landscape evolution.

This report presents the results of surficial geologic mapping in the Wittmann and Hieroglyphic Mountains SW 7.5' quadrangles located northwest of metropolitan Phoenix (Figure 1). The project area includes segments of U.S. Highway 60, State Route 79, and the Central Arizona Project Canal, and is contiguous to the south with the White Tanks Mountain piedmont area previously mapped by Field and Pearthree (1991). The surficial geology of the Phoenix North 30' X 60' quadrangle has been previously mapped at 1:100,000 scale (Demsey, 1988). The present mapping project is at 1:24,000 scale, which provides greater detail in distinguishing surfaces of different age. Surficial geologic mapping of the Wittmann and Hieroglyphic Mountains SW. 7.5-minute quadrangles was performed under the auspices of the Arizona Geological Survey with funding by the STATEMAP component of the National Geologic Mapping Program. Fieldwork was performed June through October, 1994.

PHYSICAL SETTING

The project area is located within the northwestern margin of the Phoenix Basin (Péwé, 1978) along the southwestern piedmont of the Hieroglyphic Mountains, a series of normal-faulted, basement metamorphic-plutonic rocks and mid-Tertiary volcanic and sedimentary rocks (Capps et al., 1986). Most of the bedrock exposed within the project area is composed of schist, metamorphosed granite, and rhyolite with minor outcrops of basalt. Project area landforms include alluvial fans, pediments, and stream terraces that lie

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[1] 1 My = 1,000,000 years; 1 Ma = 1 My ago; 1 ky = 1,000 years, 1 ka = 1 ky ago (North American Commission on Stratigraphic Nomenclature, 1983).

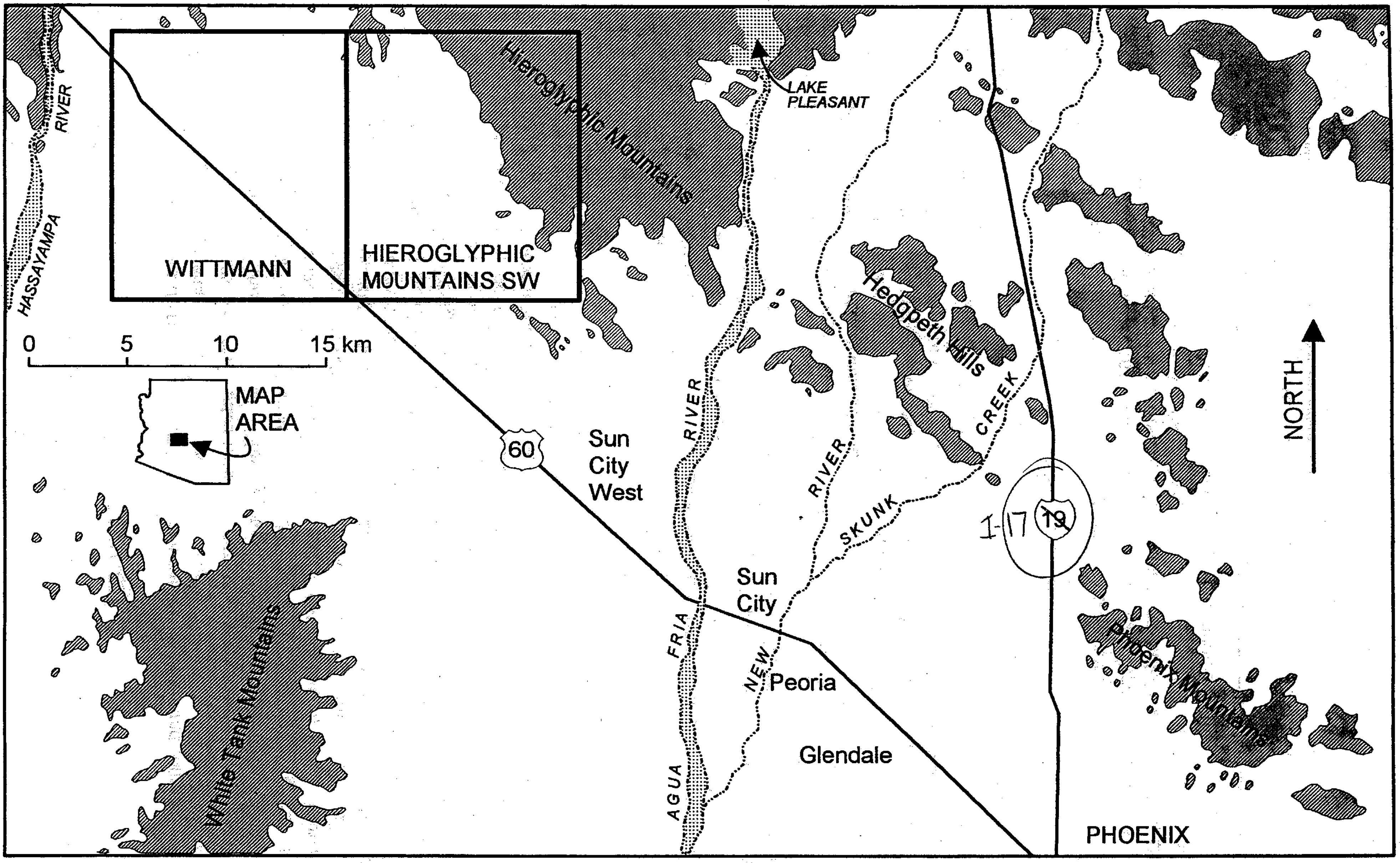

Figure 1. Location of study area in the northwestern Phoenix Basin.

between the Agua Fria and Hassayampa Rivers (Figure 1). Ephemeral streams originating in the Hieroglyphic Mountains flow southward into the basin and then southeast towards the Agua Fria River. An exception is a small area located in the northwestern corner of the Wittmann quadrangle where ephemeral streams flow southwest to the Hassayampa River. Drainages located in the southwestern corner of the Wittman quadrangle originate on the tread of an early Pleistocene terrace of the Hassayampa River (see Field and Pearthree, 1991) and flow southeastward towards the Agua Fria River.

Most of the project area is comprised of coalescing alluvial fans. Alluvial fans in the upper piedmont are moderately dissected by drainages resulting in topographically distinct landforms that are easy to map as discrete morphostratigraphic units (see Frye and Willman, 1962). In contrast, lower piedmont fan surfaces are less dissected by streams, and different aged deposits merge into one relatively smooth basin floor. Because topography is subdued in the lower piedmont, distinguishing different-aged geologic units requires greater use of surface weathering criteria such as soils.

The area has an arid, thermic climate. Elevations range 451-849 m (1480 to 2783 feet) within project area. Twenty-six years of precipitation records (1941-1966) from Wittmann indicate a mean annual temperature of 20.5° C (68.9° F) and a mean annual precipitation of 217 mm (8.5 inches) (Sellers and Hill, 1974). Vegetation in the upper piedmont is dominated by palo verde (*Cerdidium*), bursage (*Franseria*), and assorted cacti whereas the lower piedmont contains mostly creosote (*Larrea*).

METHODS

Mapping was accomplished in three stages. The first stage involved stereoscopic analysis of aerial photography. Color (1:24,000 scale) and black and white (1:40,000 scale) photography was used to analyze surface color and texture, degree of stream dissection, drainage patterns, and topography. Boundaries separating discrete deposits were traced onto mylar overlays and then transferred to 1:24,000 scale orthophotos.

The second stage involved field inspection of surfaces. Desert pavement, rock varnish, and soils were used to test boundaries defined on the aerial photography and further distinguish and correlate surfaces. Soil exposures are relatively common along stream cuts in the more dissected upper piedmont. However, to supplement these exposures and to expose soils in the relatively undissected lower piedmont, seven soil pits were excavated by backhoe. Selected soils were described according to guidelines established in the Soil Survey Manual (Soil Survey Staff, 1951; Guthrie and Witty, 1981; Appendix A) and classified to the great group level (Soil Survey Staff, 1975). The degree of calcium carbonate development, an important indicator of soil age, was described according to the morphogenetic system of Gile and others (1966) and Machette (1985). Soil maps of the project area by Camp (1986) were also utilized in analyzing soil-landform relationships.

The third stage was the correlation and age estimation of surfaces. Relative ages are provided by morphostratigraphy and weathering characteristics, but numerical age estimates are more problematic to procure. Because no locally derived numerical ages are available from the project area, age estimation of surfaces involve the long distance correlation of physical properties to areas where surface ages are constrained by paleontologic and radiometric data. Age estimates for surfaces in the Wittmann and Hieroglyphic Mountains SW quadrangles are based on correlations to the lower Colorado River Valley where landforms have numerical age control (Bull, 1991). Geologic surfaces are also correlated to the White Tank Mountains piedmont (Field and Pearthree, 1991) and piedmont areas in the eastern Phoenix Basin (Huckleberry, 1993a, 1993b, 1994).

MAPPING UNITS

Three primary mapping units are used: **Y** (young), **M** (middle or intermediate), and **O** (Old). A lower case "a" used in conjunction with the three primary symbols denotes an alluvial fan surface. The subscript "p" indicates a pediment and is used where areas of relatively low relief contain alluvium-mantled bedrock that is exposed in streamcuts. Where landforms have disturbed surfaces or surficial characteristics transitional between the three primary units, both primary units are presented, e.g., Ma2/Ya1. **Tsy** distinguishes late Tertiary basin deposits. A lone, lower case "**b**" denotes bedrock. Where map unit boundaries are indistinct, a dashed line is used; a dotted line demarcates disturbed areas (e.g., agricultural fields).

Ya2

Modern stream channels are labeled Ya2. In the Wittmann and Hieroglyphic Mountains SW quadrangles, all stream channels are ephemeral and only support short-lived discharge after sustained or heavy rains. The depth of channel entrenchment generally increases upslope such that in the upper piedmont, the height between interfluve and channel exceeds 10 m, whereas in the lower piedmont stream channels are entrenched less than 1 m. Ya2 deposits consist of stratified, poorly to moderate sorted sands, gravels, pebbles, cobbles, and boulders. These deposits are highly porous and permeable. Soils are generally absent due to a lack of time for significant pedogenesis. However, on low terraces where floods may only occur at decadal timescales, enough organic matter may accumulate at the surface forming Torrifluvent soils (Soil Survey Staff, 1975; Table 1). Ya2 surfaces are modern to historic in age, and correlate to Bull's (1991) Q4b and Field and Pearthree (1991) Y2 surfaces (Table 2).

Ya1

Relatively young alluvial fan surfaces located primarily in the lower piedmont are mapped as Ya1 (Table 1). Here, morphologically distinct fan surfaces grade into one relatively undissected valley floor. Original bar and swale topography is moderately

Table 1. Physical Characteristics and Associated Soil Types of Surficial Geologic Units.

Surface	**Stream Dissection**	**Drainage Pattern**	**Soil Horizons**	**Maximum CO_3 Stage**	**Pavement and Varnish Development**	**Associated Soil Types**	**Soil Profile (Appendix A)**
Ya2	-	-	C	-	none	Torrifluvent	-
Ya1	< 2 m	distributary and dendritic	Bw, Bt, Bk, CBk, C	I+	none to weak	Torriorthent Camborthid Calciorthid	WT1, WT3, WT7
Ma2	1-5 m	dendritic	Av, Bt, Bk, Bkm	III	weak to moderate	Calciorthid Haplargid	WT5
Ma1	2-10+ m	dendritic	Av, Bt, Bk, Bkm, Bqm, Bkqm	IV	weak to strong	Paleargid Durargid	WT4, WT8
Oa	> 6 m	dendritic	Bt, Bk, Bkm, Bkqm	V	weak to strong	Paleargid Durargid Paleorthid Durorthid	WT6

Table 2. Surface Correlations and Age Estimates.

Surface	Age Estimate	Correlated Surface Lower Colorado River Valley Bull (1991)	Correlated Surface White Tank Mountains Field and Pearthree (1991)
Ya2	< 0.5 ka	Q4b	Y2
Ya1	< 10 ka	Q4a, Q3	Y2, Y1
Ma2	10-200 ka	Q2c, Q2b	M2, M1b
Ma1	200-500 ka	Q2a	M1a
Oa	0.5-1.6 Ma	Q1	M1a, O

preserved, and mounds of sediment at the bases of creosote bushes suggest that there has been some eolian reworking of surface materials. Drainage patterns range between distributary and dendritic with the former dominant where channels are incised < 1 m and prone to lateral shifting. Ya1 deposits are characterized by stratified, poorly to moderately sorted sands, gravels, and cobbles frequently mantled by sandy loam sediment. Soil development is relatively weak with only slight texturally or structurally modified B horizons and slight calcification (Stage I). Some of the older Ya1 soils may contain weakly developed argillic horizons. Ya1 soils classify as Torriorthents, Camborthids, and Calciorthids (Soil Survey Staff, 1975). Because surface soils are not indurated with clay or calcium carbonate, Ya1 surfaces have relatively high permeability and porosity and are thus good surfaces for groundwater recharge. An exception is where Ya1 deposits unconformably overlie older fan deposits with indurated soils. Ya1 surfaces are Holocene in age (< 10 ka) and correlate to Bull's (1991) Q4a and Q3 and Field and Pearthree's (1991) Y2 and Y1 surfaces (Table 2).

Ma2

The younger Pleistocene fan surfaces are labeled Ma2 (Table 1). Ma2 surfaces are moderately incised by stream channels but still contain constructional, relatively flat interfluvial surfaces with weak to moderate desert pavement development. In the southwestern part of the Wittmann quadrangle, Ma2 surfaces are composed of gravelly fan channel deposits that now form topographic highs above Ya1 surfaces (see DISCUSSION below). Overall, Ma2 deposits range in size from cobbles to sand, but Ma2 soils contain much pedogenic clay and calcium carbonate resulting relatively low infiltration rates. Ma2 soils classify as Calciorthids and Haplargids (Soil Survey Staff, 1975). Gravelly soils display the greatest calcification, and the older Ma2 soils can have Stage III calcium carbonate development. Ma2 surfaces are age estimated at 10-200 ka and correlate to Bull's (1991) Q2c and Q2b surfaces and Field and Pearthree's (1991) M2 and M1b surfaces. Although Field and Pearthree (1991) estimated the M1b surface to be 150-300 ka, they describe associated soils as having only "weak argillic" horizons and Stage II carbonate morphology suggesting an age less than 200 ka.

Ma1

Ma1 surfaces are concentrated in the upper piedmont where channel incision has transformed older fan surfaces into a series of ridges and swales. A prominent area of Ma1 surfaces occurs in the Hieroglyphic Mountains SW quadrangle and is associated with a dissected fan whose apex is located in sections 10 and 15, T.6 N., R. 2 W. The apex still contains a flat constructional surface overlying pediment, but elsewhere Ma1 surfaces are more undulating. Ma1 soils are thick and well developed with argillic, duric, and petrocalcic horizons. These soils classify as Durargids and Paleargids (Soil Survey Staff, 1975). The combination of indurated soils and moderate to steep slopes precludes substantial surface infiltration into Ma1 deposits. Ma1 surfaces are estimated to be 200-500 ky old (Table 2) and correlate to Bull's (1991) Q2a and Field and Pearthree's (1991) M1a surfaces.

Oa

Old dissected fan deposits located in the northern part of the Wittmann quadrangle are mapped as Oa. Oa topography is predominantly ridge and swale with few preserved constructional alluvial fan surfaces. Oa surfaces in the Wittmann quadrangle contain a lag of dark, reddish-brown, rhyolite porphyry that contrasts with adjacent younger surfaces that are covered predominantly with quartz and potassium feldspar granules. The predominance of rhyolite clasts on Oa surfaces probably reflects both the resistance of rhyolite to weathering (thus, rhyolite is preserved while other lithologies disintegrate) and the period of deposition when there was more Tertiary volcanic bedrock exposed in the watershed. Either hypothesis points to the great antiquity of these surfaces. Oa soils are also very old consisting of degraded petrocalcic horizons with Stage IV and V development (Table 1). Unlike most Oa surfaces mapped elsewhere in the Phoenix Basin (e.g., Huckleberry, 1993b), petrocalcic fragments are uncommon on these Oa surfaces. Instead, younger pedogenic horizons developed out of the degraded petrocalcic horizon commonly mantle the surface (see Soil Profile WT6). Oa soils generally classify as Durorthids and Paleorthids (Soil Survey Staff, 1975) but also Durargids and Palargids where argillic horizons are developed into the younger debris of the degraded soil. Moderate to steep slopes and indurated soil horizons limit infiltration on Oa surfaces. Oa surfaces correlate to Bull's (1991) Q1 surface and Field and Pearthree's (1991) O and older Ma1 surfaces (Table 2). A reasonable age estimate for Oa surfaces is 0.5 to 1.6 Ma, i.e., early to middle Pleistocene.

Tsy

In the far northwestern corner of the Wittmann quadrangle near Morristown is an area where basin deposits are highly dissected by tributary streams to the Hassayampa River. These are erosional landforms where overlying Quaternary deposits have been eroded exposing older sediments. These surfaces are labeled Tsy because they are probably composed of late Tertiary sediments. Streamcuts expose moderately sorted sands, gravels, cobbles, and boulders with gently dipping beds. These deposits are commonly cemented with calcium carbonate; some calcareous horizons are greater than 5 m thick. Tsy sediments were deposited after the waning stages of the Basin and Range faulting during the late Miocene and Pliocene, approximately 1.6-5.0 Ma.

DISCUSSION

The distribution of alluvial deposits in the Hieroglyphic Mountains piedmont area is similar to that found throughout the Phoenix Basin: late Tertiary and early to middle Quaternary fan deposits are located close to the mountain front whereas late Quaternary deposits are pervasive in the lower piedmont areas. The oldest piedmont deposits tend to be river terraces found along the larger rivers (e.g., Salt, Agua Fria, and Hassayampa Rivers) that are older than 1 My. In the project area, the oldest preserved surfaces are approximately 0.5-1.0 My old, although older fan deposits are exposed in eroded ridges (e.g., Oa and Tsm). Younger landforms tend to be alluvial fans derived partly from degrading older fans in the upper piedmont. Throughout the Quaternary, the piedmonts have experienced overall degradation with episodic periods of aggradation or stability. This is supported not only by alluvial fan morphostratigraphy but also by suites of stream terraces that have formed along the larger Phoenix Basin streams (Péwé, 1978; Morrison, 1985; Huckleberry, 1993a).

One noteworthy line of evidence for alternating deposition and erosion in the Wittmann quadrangle is where Ma2 deposits exhibit evidence of topographic reversal. As previously mentioned, Ma2 deposits in the southwest part of the Wittmann quadrangle form subdued ridges above Ya1 deposits. These ridges are composed of highly calcified channel gravels and contain moderately varnished desert pavements. Viewed from the air, these deposits appear as dark plumose or dendritic forms, and are recognizeable on the Soil Conservation Service's soil map (Camp, 1986). These are remnants of fan deposits that have been eroded. The gravels were deposited in distributary channels, probably on the distal portions of the fan system. The channels were subsequently abandoned, and the gravels became cemented with pedogenic calcium carbonate giving them greater strength and resistance to erosion. Subsequent erosion removed adjacent, fine-textured sediments resulting in formerly low areas becoming topographic highs.

Although climate change and its effect on fluvial systems is the primary driving force in Quaternary landscape evolution in the Phoenix Basin, not all geomorphic changes are climatic in origin. Indeed, some fluvial dynamics are intrinsic (see Schumm, 1973) and can play an important role in landscape evolution. For example, in the Hieroglyphic Montains piedmont area, stream channel geometry varies with degree of entrenchment. Specifically, stream channels are more sinuous in the upper piedmont where they are more deeply incised. In contrast, fan channels in the lower piedmont and those draining the backside of the Hassayampa Pleistocene Terrace in the southwestern part of the project area have linear alignments. This suggests that channel geometry evolves from linear to sinuous as fans become entrenched regardless of the direction of climate change. Similar channel transformation occur in arroyos in ephemeral and intermitent, gravel-dominant streams where gravel bars accumulate in the channel and deflect small and moderate streamflow into channel walls resulting in a meandering flow pattern and overall channel widening (Meyer, 1989). Eventually, the entrenched fan channels in the Hieroglyphic Mountains piedmont will merge, the older dissected fan deposits will be destroyed, and a new fan system will form. Hence, in this case, climate change need not be invoked for the landscape change.

Age assignment and correlation of basin deposits in the Wittmann and Hieroglyphic Mountains SW quadrangles are generally congruent with those made by Demsey (1988) and Field and Pearthree (1991). There are, however, some noteworthy differences. The southwest corner of the Wittmann quadrangle includes a large area of low relief that grades to the west with an early Pleistocene terrace of the Hassayampa River. Within the Wittmann quadrangle, this surface is mapped as Ma2 based primarily on soils which are moderately developed Haplargids with Stage II carbonate development.

Demsey (1988) maps this surface as O, and Field and Pearthree (1991) map this surface in the southern adjacent quadrangle (White Tank Mountains Northwest) as M1. These discrepancies reflect the difficulties in defining geologic boundaries on the backside of stream terraces, i.e., away from the river. The highest Hassayampa terrace contains early Pleistocene soils near the terrace scarp but this surface gradually becomes buried by younger alluvium to the east. The boundary between the original terrace tread and the younger overlying alluvium is difficult to identify in the field or from soil maps. Thus within the Wittmann quadrangle, this surface is appropriately identified as late Pleistocene in age (Ma2) whereas in areas to the south and west, the surface may be better identified as middle (Ma1) or possibly early Pleistocene (O) in age.

Finally, the ages of some of the other surfaces mapped during this project are interpreted as younger than those estimated by Demsey (1988). These discrepancies usually consist of surfaces identified as O and M1 by Demsey being mapped as Ma1 and Ma2, respectively, in this study. The younger age estimates on the Wittmann and Hieroglyphic Mountains SW 7.5-minute quadrangles are supported by greater field inspection and pedologic criteria and are more accurate. However, local chronological control for these surfaces is still lacking, and the age ranges presented here for Pleistocene surfaces should be considered approximate. Such uncertainties will only be remedied in the future by independent numerical age control.

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APPENDIX A: SOIL PROFILE DESCRIPTIONS

Geologic Surface: Ya1
Soil Profile: WT1b
Classification: Camborthid
Location: Maricopa County, Arizona; SE 1/4, SE 1/4, SE 1/4, Sec. 22, T. 5 N., R. 3 W.
Physiographic Position: Alluvial fan; elevation 500 m.
Topography: Gentle, 1% slope
Vegetation: Creosote (*Larrea*).
Described by: Gary Huckleberry, September 27, 1994.
Remarks: Soil profile located approximately 60 m from corner section marker. 3Bk1 still retains some of its primary bedforms. Charcoal fragment collected from 3Bk3 horizon at 114 cm depth. Soil colors are for dry conditions.

Bw 0-12 cm. Light yellowish brown (10YR 6/4) silt loam; moderate, very coarse, platy and subangular blocky structure; slightly hard (dry), not sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

C1 12-35 cm. Light yellowish brown (10YR 6/4) sandy loam; massive; slightly hard (dry), not sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

2C 35-40 cm. Small cobbles, gravels, and coarse sand; single grain; noneffervescent; abrupt smooth boundary.

3Bk1 Yellowish brown (10YR 5/4) silty clay loam; hard (dry), sticky and very plastic (wet); violently effervescent; carbonates are disseminated and occur as common, very fine filaments (Stage I); abrupt smooth boundary.

3Bk2 Light yellowish brown (10YR 6/4) sandy loam; massive; slightly hard (dry), slightly sticky and plastic (wet); strongly effervescent; carbonates are disseminated; abrupt smooth boundary.

3Bk3 Yellowish brown (10YR 5/4) very fine loamy sand; massive; soft (dry), not sticky and not plastic (wet); slightly effervescent; carbonates are disseminated.

Geologic Surface: Ya1
Soil Profile: WT3
Classification: Camborthid
Location: Maricopa County, Arizona; SE 1/4, SE 1/4, SW 1/4, Sec. 31, T. 6 N., R. 3 W.
Physiographic Position: Alluvial fan; elevation 560 m.
Topography: Gentle, 1% slope
Vegetation: Creosote (*Larrea*), bursage (*Franseria*).
Described by: Gary Huckleberry, September 27, 1994.
Remarks: Soil profile located approximately 30 m north of section-line fence. Soil colors are for dry conditions.

A 0-2 cm. Pale brown (10YR 6/3) fine loamy sand; weak, coarse, platy structure; soft (dry), not sticky and not plastic (wet); noneffervescent; abrupt smooth boundary.

Bw 2-27 cm. Brown to strong brown (7.5YR 5/5) sandy loam; weak, coarse, angular blocky structure; soft (dry), not sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bk2 27-45 cm. Brown to strong brown (7.5YR 5/5) sandy loam; massive; soft (dry), not sticky and slightly plastic (wet); strongly effervescent; carbonates are disseminated; clear smooth boundary.

Bk3 45-70 cm. Yellowish brown (10YR 5/4) gravelly sandy loam; massive; soft (dry), not sticky and slightly plastic (wet); violently effervescent; carbonates are disseminated and occur as discontinuous rinds on clasts (Stage I); abrupt wavy boundary.

2Bk 70-110+ cm. Yellowish brown (10YR 5/4) pebbles in coarse, loamy sand matrix; single grain; loose (dry), not sticky and not plastic (wet); violently effervescent; carbonates are disseminated and occur as discontinuous rinds on clasts (Stage I).

Geologic Surface: Ya1
Soil Profile: WT7
Classification: Calciorthid
Location: Maricopa County, Arizona; NE 1/4, NW 1/4, NE 1/4, Sec. 15, T. 5 N., R. 2 W.
Physiographic Position: Alluvial fan; elevation 506 m.
Topography: Gentle, 1% slope
Vegetation: Creosote (*Larrea*), bursage (*Franseria*).
Described by: Gary Huckleberry, September 27, 1994.
Remarks: Soil profile located approximately 10 m south of section-line fence. Soil colors are for dry conditions.

A 0-2 cm. Pale brown (10YR 6/3) very fine loamy sand; moderate, very coarse, platy structure; soft (dry), not sticky and not plastic (wet); noneffervescent; abrupt smooth boundary.

Bw 2-22 cm. Light yellowish brown (10YR 6/4) very fine loamy sand; moderate, very coarse, angular blocky structure; slightly hard (dry), not sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bk 22-40 cm. Light yellowish brown (10YR 6/4) sandy loam; weak, coarse, subangular blocky structure; slightly hard (dry); not sticky and slightly plastic (wet); violently effervescent; carbonates are disseminated; abrupt smooth boundary.

2Bk 40-100+ cm. Light brownish gray (10YR 6/2) cobbles and gravels in a loamy coarse sand matrix; single grain; loose (dry), not sticky and not plastic (wet); violently effervescent; carbonates are disseminated and occur as discontinuous rinds on clasts (Stage I+).

Geologic Surface: Ma1
Soil Profile: WT5
Classification: Haplargid
Location: Maricopa County, Arizona; NW 1/4, NW 1/4, NW 1/4, Sec. 24, T. 6 N., R.3 W.
Physiographic Position: Alluvial fan; elevation 631 m.
Topography: 1-2% slope
Vegetation: Creosote (*Larrea*), palo verde (*Cercidium*), and bursage (*Franseria*).
Described by: Gary Huckleberry, October 4, 1994.
Remarks: Soil profile located approximately 40 m south of section line. Soil colors are for dry conditions.

A 0-3 cm. Reddish yellow (7.5YR 7/6) sandy loam; weak, medium, subangular blocky structure; soft (dry), not sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

Bt1 3-22 cm. Yellowish red (5YR 5/6) sandy clay; hard (dry), sticky and very plastic (wet); noneffervescent; many, faint clay skins as bridges between sand grains and as colloidal stains; clear smooth boundary.

Btk2 22-52 cm. Yellowish red (5YR 5/6) sandy clay; extremely hard (dry), sticky and very plastic (wet); slightly effervescent; carbonates occur as few, distinct, fine filaments and few, fain, coatings on ped faces (Stage I); common, distinct clay skins on ped faces and as bridges between sand grains; clear smooth boundary.

Bt3 52-100 cm. Reddish yellow (7.5YR 6/6) gravelly loamy sand; massive; loose (dry), slightly sticky and slightly plastic (wet); noneffervescent; few, faint, clay skins as bridges between sand grains; abrupt, wavy boundary.

Cox 100-125+ cm. Pink (7.5YR 7/4) gravelly very coarse sand; single grain; loose (dry), not sticky and not plastic (wet); noneffervescent.

Geologic Surface: Ma1
Soil Profile: WT8
Classification: Paleargid
Location: Maricopa County, Arizona; SE 1/4, SW 1/4, SW 1/4, Sec. 11, T. 5 N., R. 2 W.
Physiographic Position: Alluvial fan; elevation 506 m.
Topography: Gentle, 1% slope
Vegetation: Creosote (*Larrea*), bursage (*Franseria*), cholla (*Opuntia*).
Described by: Gary Huckleberry, September 27, 1994.
Remarks: Soil profile located approximately 20 m north of section-line fence. Soil colors are for dry conditions.

A 0-1 cm. Yellow (10YR 7/6) gravelly sandy clay loam; moderate, coarse, platy and medium, angular blocky structure; slightly hard (dry), slightly sticky and very plastic (wet); noneffervescent; abrupt smooth boundary.

Bt 1-22 cm. Strong brown (7.5YR 5/6) sandy clay; moderate, coarse, angular blocky structure; slightly hard (dry), sticky and very plastic (wet); noneffervescent; many, distinct, clay skins on ped faces; clear smooth boundary.

Btk 22-40 cm. Reddish yellow (7.5YR 7/6) very gravelly sandy clay loam with many, prominent, white (7.5YR 8/2) mottles; massive; very hard (dry), very sticky and very plastic (wet); violently effervescent; carbonates are disseminated and occur as many filaments and coatings on ped faces; common, distinct, clay skins on ped faces; clear smooth boundary.

Bkm 40-130+ cm. White (7.5YR 8/2) petrocalcic horizon; approximately 50% gravel; extremely hard; violently effervescent; indurated with calcium carbonate (Stage III+).

Geologic Surface: Ma1
Soil Profile: WT4
Classification: Paleargid
Location: Maricopa County, Arizona; NW 1/4, SE 1/4, SE 1/4, Sec. 22, T. 6 N., R.3 W.
Physiographic Position: Alluvial fan; elevation 616 m.
Topography: Gentle, 1% slope
Vegetation: Creosote (*Larrea*), Palo Verde (*Cercidium*)
Described by: Gary Huckleberry, October 4, 1994.
Remarks: Soil profile located adjacent to two-track road. Moderately developed desert pavement with 30-70% coverage. Soil colors are for dry conditions.

A 0-2 cm. Light brown (7.5YR 6/4) gravelly sandy loam; weak, medium, platy and angular blocky structure; soft (dry), not sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

Bt1 2-30 cm. Yellowish red (5YR 4/6) sandy clay; strong, very coarse, angular blocky structure; extremely hard (dry), very sticky and very plastic (wet); noneffervescent; many, prominent, clay skins on ped faces and as colloidal stains; gradual, smooth boundary.

Btk2 30-55 cm. Yellowish red (5YR 4/6) clay; strong, medium to coarse, angular blocky structure; extremely hard (dry), very sticky and very plastic (wet); slightly effervescent; carbonates occur as few, prominent, very fine filaments (Stage I); many, prominent, clay skins on ped faces and as colloidal stains; clear, smooth boundary.

Btk3 55-74 cm. Yellowish red (5YR 5/6) sandy clay; massive; extremely hard (dry), very sticky and very plastic (wet); strongly effervescent; carbonates occur as common, prominent, very fine filaments (Stage I); common, distinct, clay skins as bridges between sand grains and as colloidal stains; clear, smooth boundary.

Btk4 74-99 cm. Reddish yellow (7.5YR 6/6) gravelly sandy clay; massive; extremely hard (dry), sticky and very plastic (wet); strongly effervescent; carbonates occur as few, prominent, very fine filaments (Stage I); common, distinct, clay skins as bridges between sand grains and as colloidal stains; clear smooth boundary.

Bkm 99-140+ cm. Pinkish white (5YR 8/2), gravelly, massive; extremely hard (dry); violently effervescent; indurated with calcium carbonate (Stage III+).

Geologic Surface: Oa
Soil Profile: WT6
Classification: Paleorthid
Location: Maricopa County, Arizona; NW 1/4, NE 1/4, NW 1/4, Sec. 24, T. 6 N., R.3 W.
Physiographic Position: Alluvial fan; elevation 631 m.
Topography: 1-2 % slope
Vegetation: Creosote (*Larrea*), palo verde (*Cercidium*), bursage (*Franseria*)
Described by: Gary Huckleberry, October 4, 1994.
Remarks: Soil profile located approximately 20 m south of section line. Petrocalcic horizon is degrading with younger soil developed into debris. Moderately varnished pavement with 50-90% coverage. Soil colors are for dry conditions.

A 0-2 cm. Light yellowish brown (10YR 6/4) sandy loam; moderate, coarse angular blocky and very coarse platy structure; soft (dry), slightly sticky and plastic (wet); strongly effervescent; carbonates are disseminated; abrupt smooth boundary.

Bk1 2-16 cm. Light yellowish brown (10YR 6/4) gravelly sandy loam; weak to moderate, coarse angular blocky structure; soft (dry), slightly sticky and plastic (wet); violently effervescent; carbonates are disseminated and occur as discontinuous rinds on clasts (Stage I); clear smooth boundary.

Bk2 16-42 cm. Light yellowish brown (10YR 6/4) gravelly sandy loam; single grain; loose (dry), slightly sticky and slightly plastic (wet); violently effervescent; carbonates are disseminated; abrupt smooth boundary.

2Bkm 42-67 cm. White (10YR 8/1), massive; extremely hard; violently effervescent; indurated carbonate with brecciated laminar cap (Stage V); abrupt wavy boundary.

2Bk2 67-110+ cm. Light gray (10YR 7/2) very gravelly, coarse sand; single grain; loose (dry), not sticky and not plastic (wet); violently effervescent; carbonates are disseminated and form thick pendants on the bottoms of clasts (Stage I+).

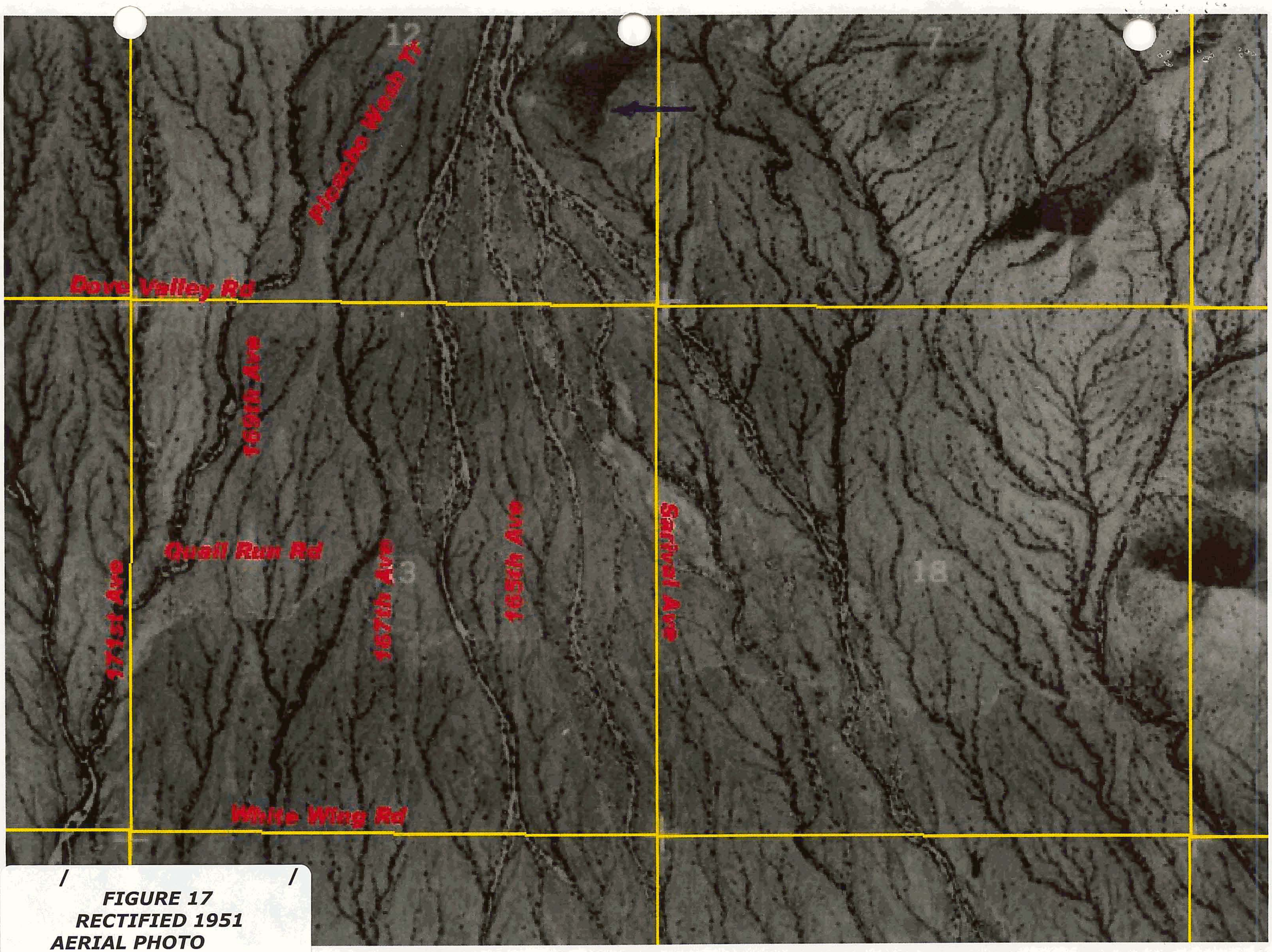


FIGURE 17
RECTIFIED 1951
AERIAL PHOTO

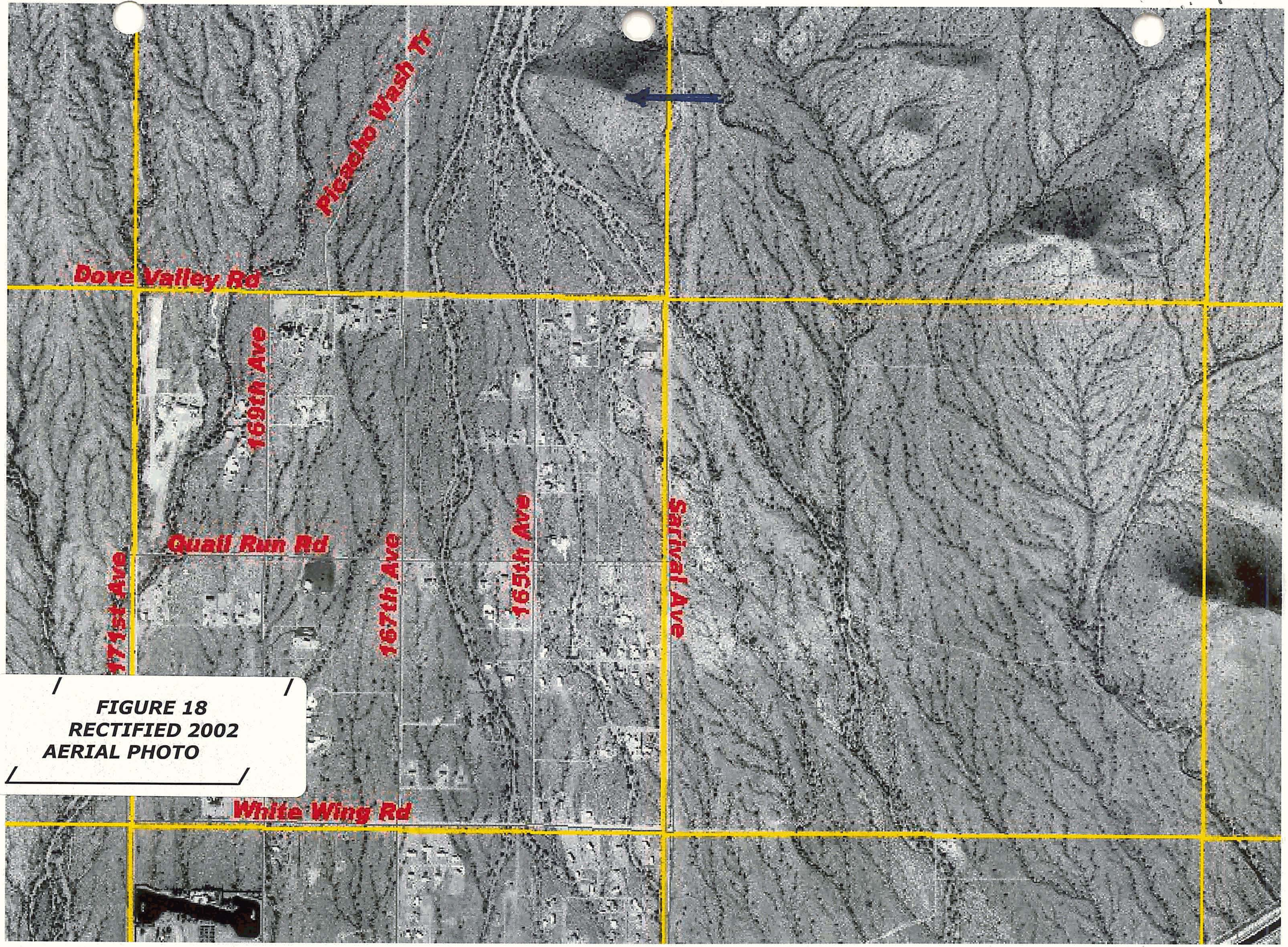


FIGURE 18
RECTIFIED 2002
AERIAL PHOTO

Geologic Surface: Oa
Soil Profile: WT9
Classification:
Location: Maricopa County, Arizona; SW 1/4, NW 1/4, Sec. 15, T. 6 N., R.2 W.
Physiographic Position: Alluvial fan; elevation 683 m.
Topography: 1-2 % slope
Vegetation: Creosote (*Larrea*), palo verde (*Cercidium*), cholla (*Opuntia*)
Described by: Gary Huckleberry, May 12, 1995.
Remarks: Soil profile located approximately 20 m west of improved dirt road. Argillic horizon is degrading the upper part of the petrocalcic horizon. No distinct pavement; only < 10 % pebbles at surface. Soil colors are for dry conditions.

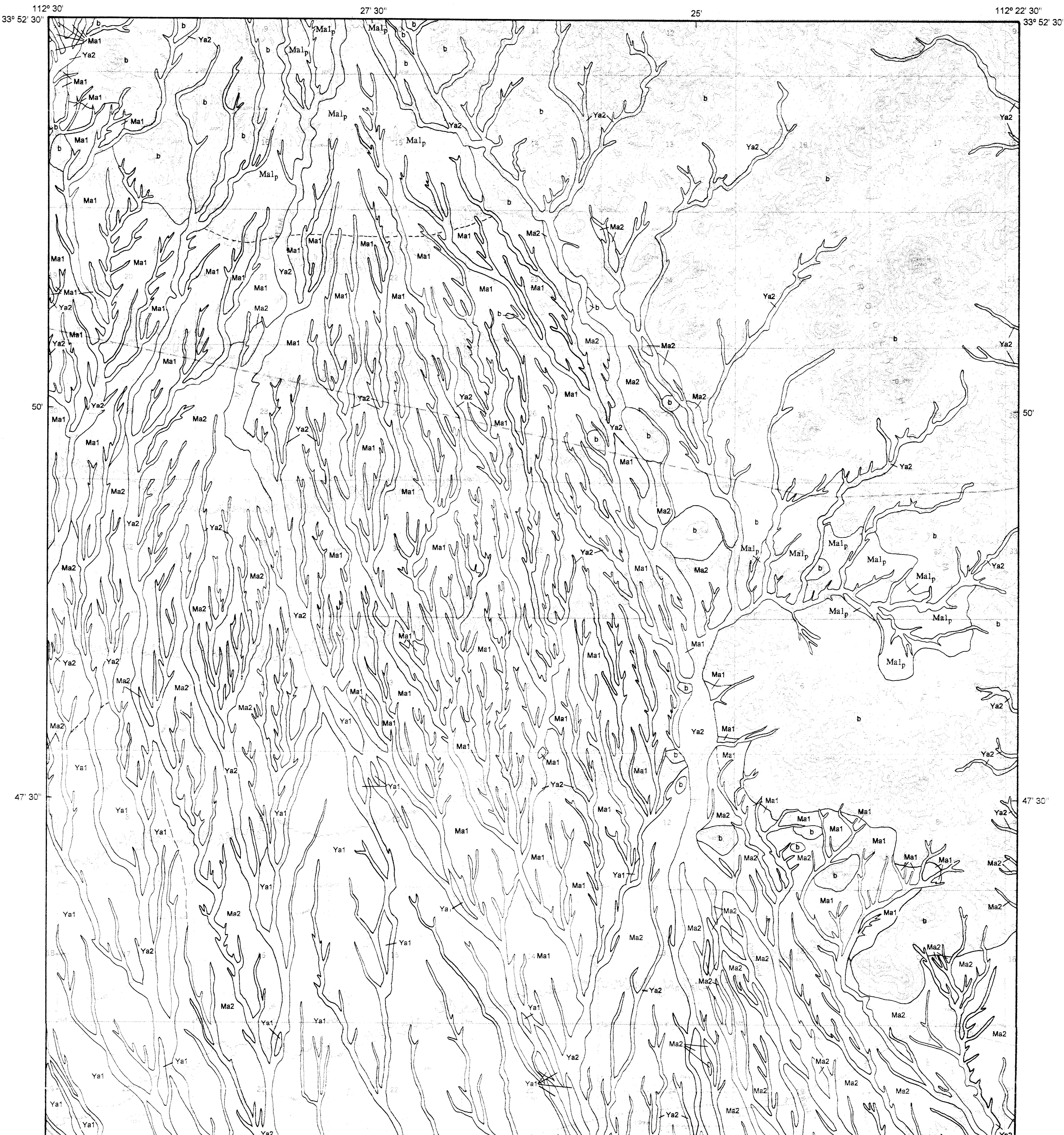
ABw 0-15 cm. Light brown (7.5YR 6/4) gravelly loam; strong, very coarse, angular blocky structure; slightly hard (dry); slightly sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

Bt1 15-35 cm. Brown (7.5YR 4.5/4) clay; strong, very coarse, prismatic structure; extremely hard (dry); very sticky and very plastic (wet); noneffervscent; many, distinct, clay skins on ped faces; clear smooth boundary.

Btk2 35-50 cm. Strong brown (7.5YR 4/6) clay; strong, very coarse, prismatic structure; extremely hard (dry), very sticky and very plastic (wet); slightly effervescent; carbonates are disseminated; many, prominent, clay skins on ped faces; abrupt wavy boundary.

Btk3 50-75 cm. Brown to dark brown (7.5YR 4/4) extremely gravelly sandy clay; single grain; loose (dry); very sticky and very plastic (wet); strongly effervescent; carbonates form discontinuous rinds on clasts and common mottles in matrix (Stage I+); many, distinct, clay skins forming colloidal stains and bridges on clasts; abrupt wavy boundary.

2Bkqm 75-160+ cm. Pinkish white (7.5YR 8/2) gravels and cobbles; massive; extremely hard; violently effervescent; carbonates indurate horizon (Stage IV+).



SCALE 1:24,000

1 .5 0 1 MILE

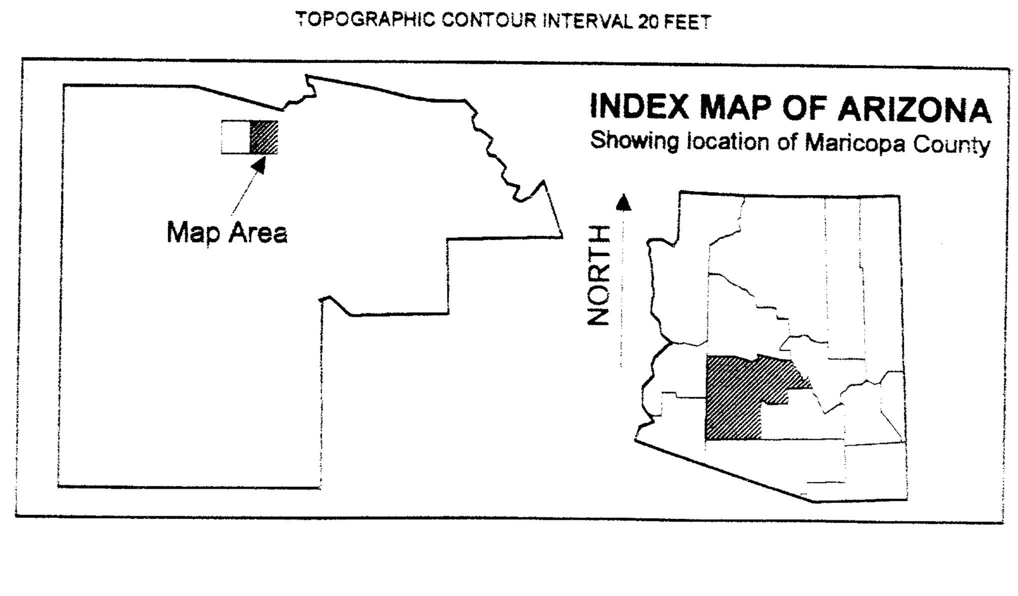
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 20 FEET

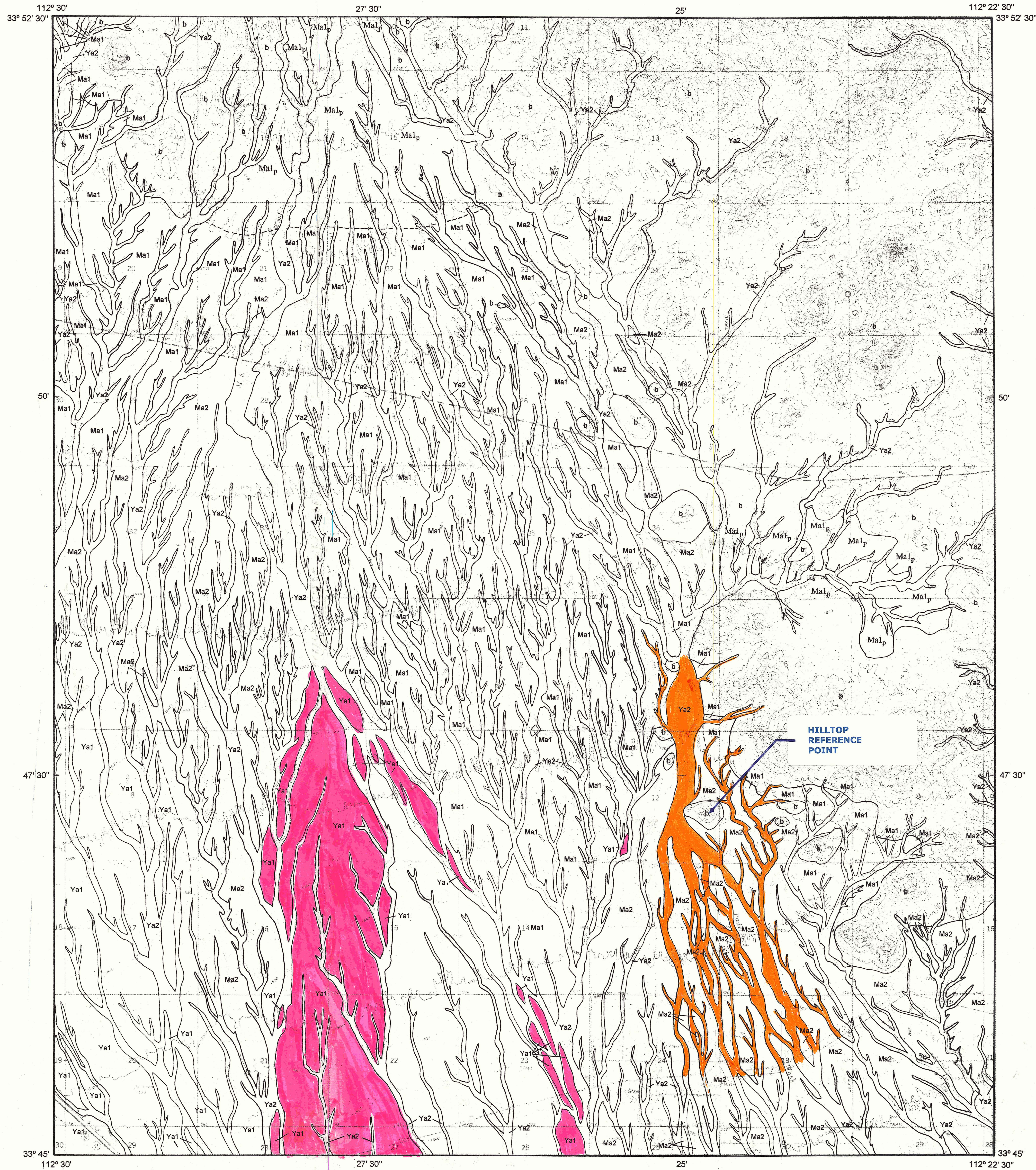
Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona

by
Gary Huckleberry



ARIZONA GEOLOGICAL SURVEY
Open-File Report 94-21, sheet 2 of 2, with text

Hieroglyphic Mountains Southwest Quadrangle



SCALE 1:24,000

1 MILE

7000 FEET

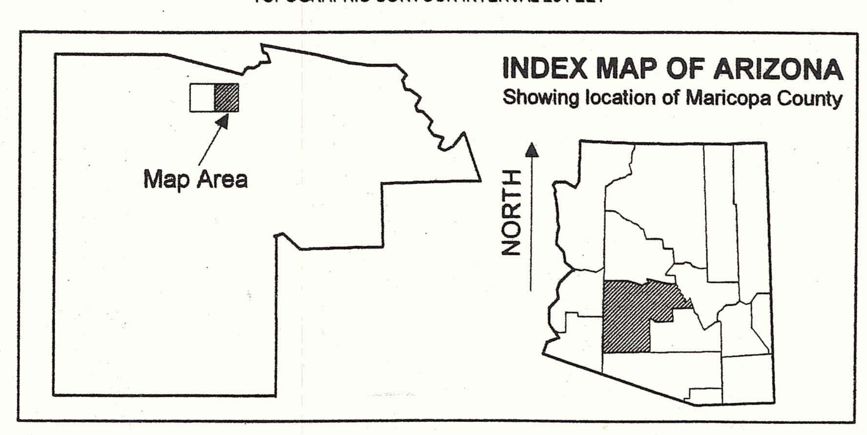
1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 20 FEET

Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona

by

Gary Huckleberry



ARIZONA GEOLOGICAL SURVEY
Open-File Report 94-21, sheet 2 of 2, with text

Hieroglyphic Mountains Southwest Quadrangle

SURFACE I.D.	AGE ESTIMATE (yr)
Ya2 of Lower Padelford Wash	less than 500
Ya1	less than 10,000
[ ] Ma2	10,000 to 200,000
[ ] Ma1	200,000 to 500,000

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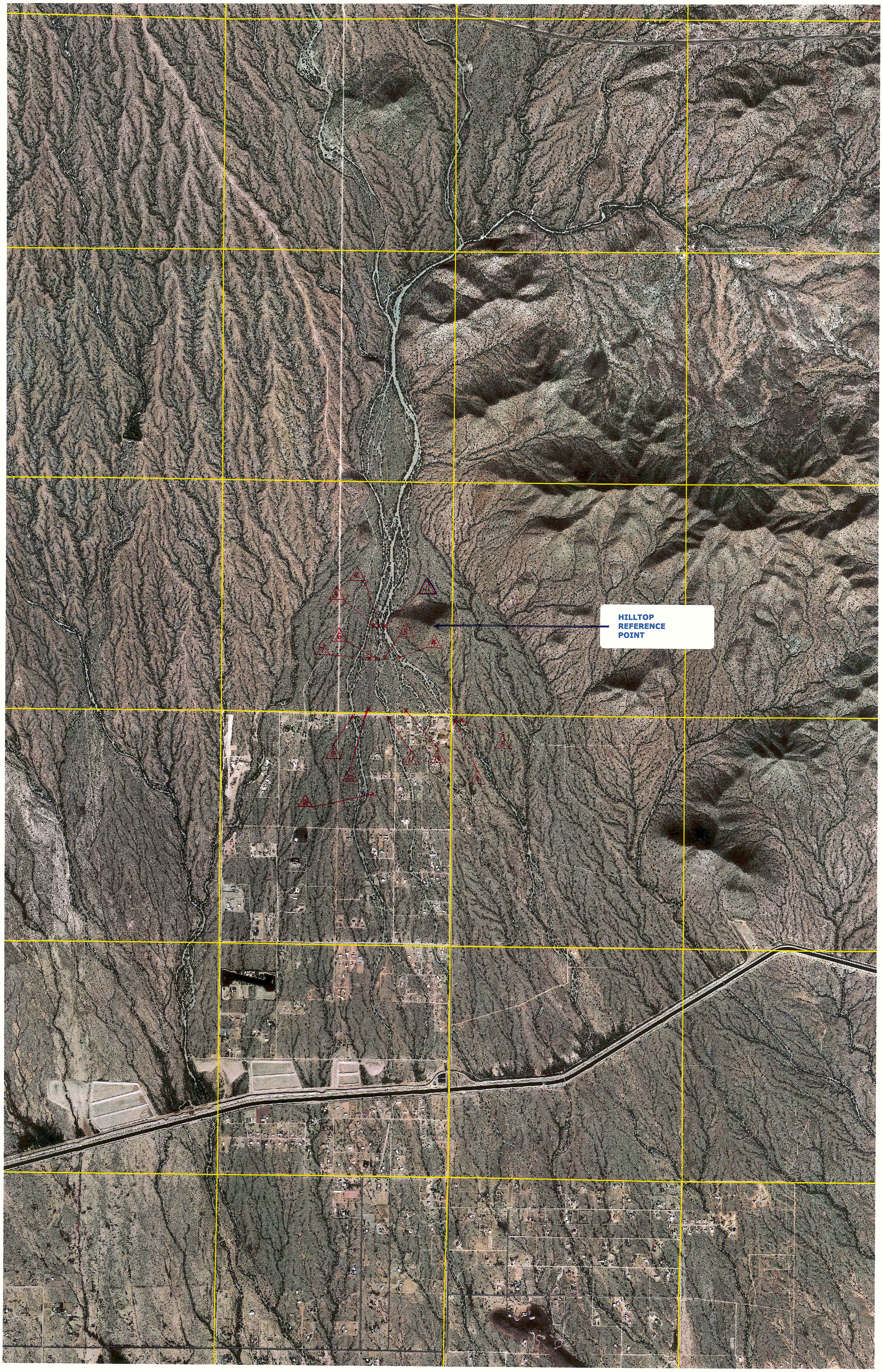

PADELFORD WASH F.D.S.
AERIAL PHOTO WITH GROUND-PHOTO LOCATIONS

0 1000 2000 3000 Feet

2002 PHOTO

N

FCD COPY

FIGURE 1-A
LOCATION 1
LOOKING EAST

FIGURE 1-B
LOCATION 1
LOOKING SOUTH

FIGURE 2
LOCATION 2
LOOKING SOUTH

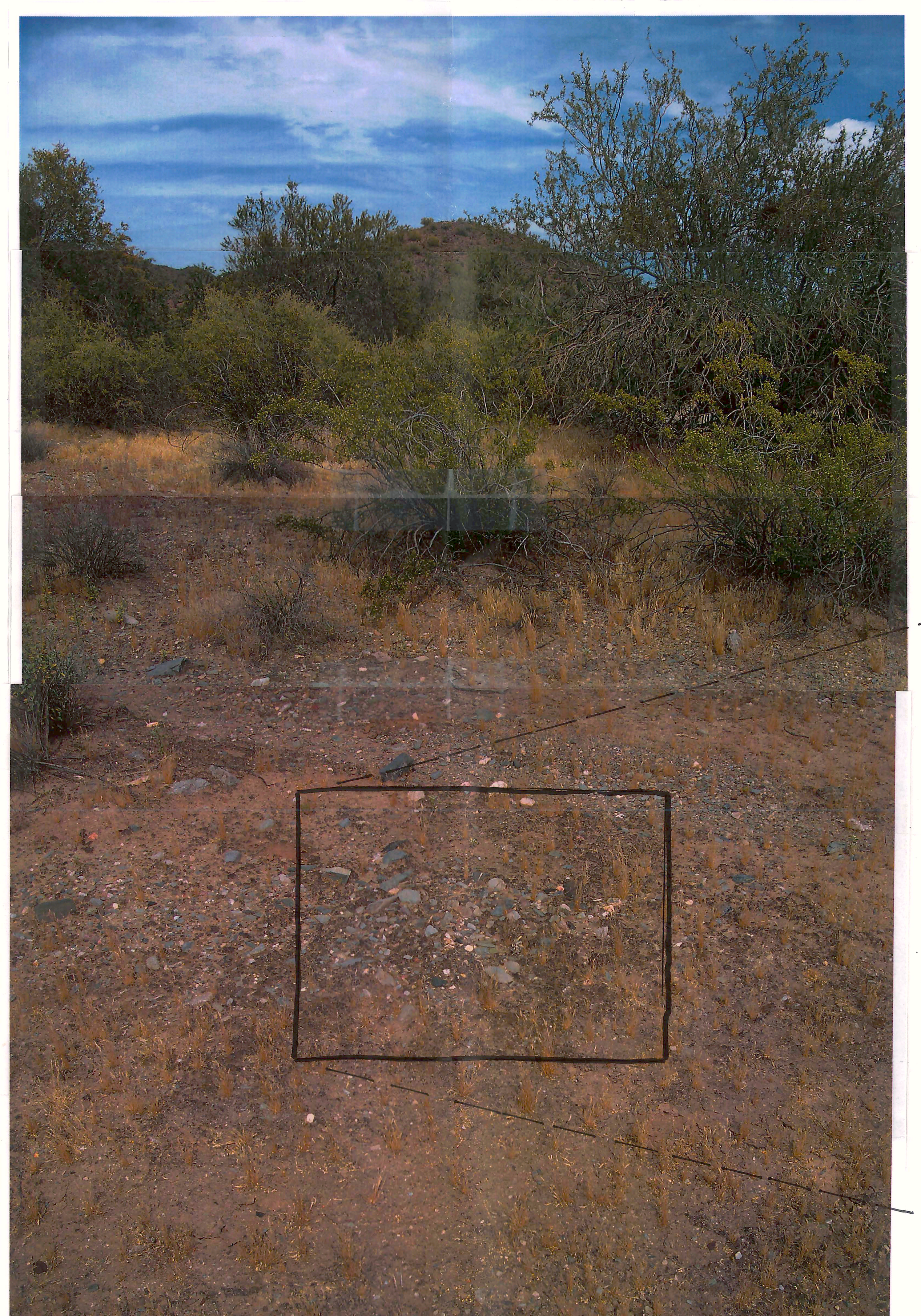

FIGURE 3-A
LOCATION 3
LOOKING EAST

FIGURE 3-B
CLOSE-UP
OF FIG. 3-A

PADELFORD WASH FLOODPLAIN DELINEATION STUDY	SHEET 1 OF 4
GROUND PHOTOS AT LOWER PORTION OF STUDY	

FIGURE 4
LOCATION 4
LOOKING SOUTH

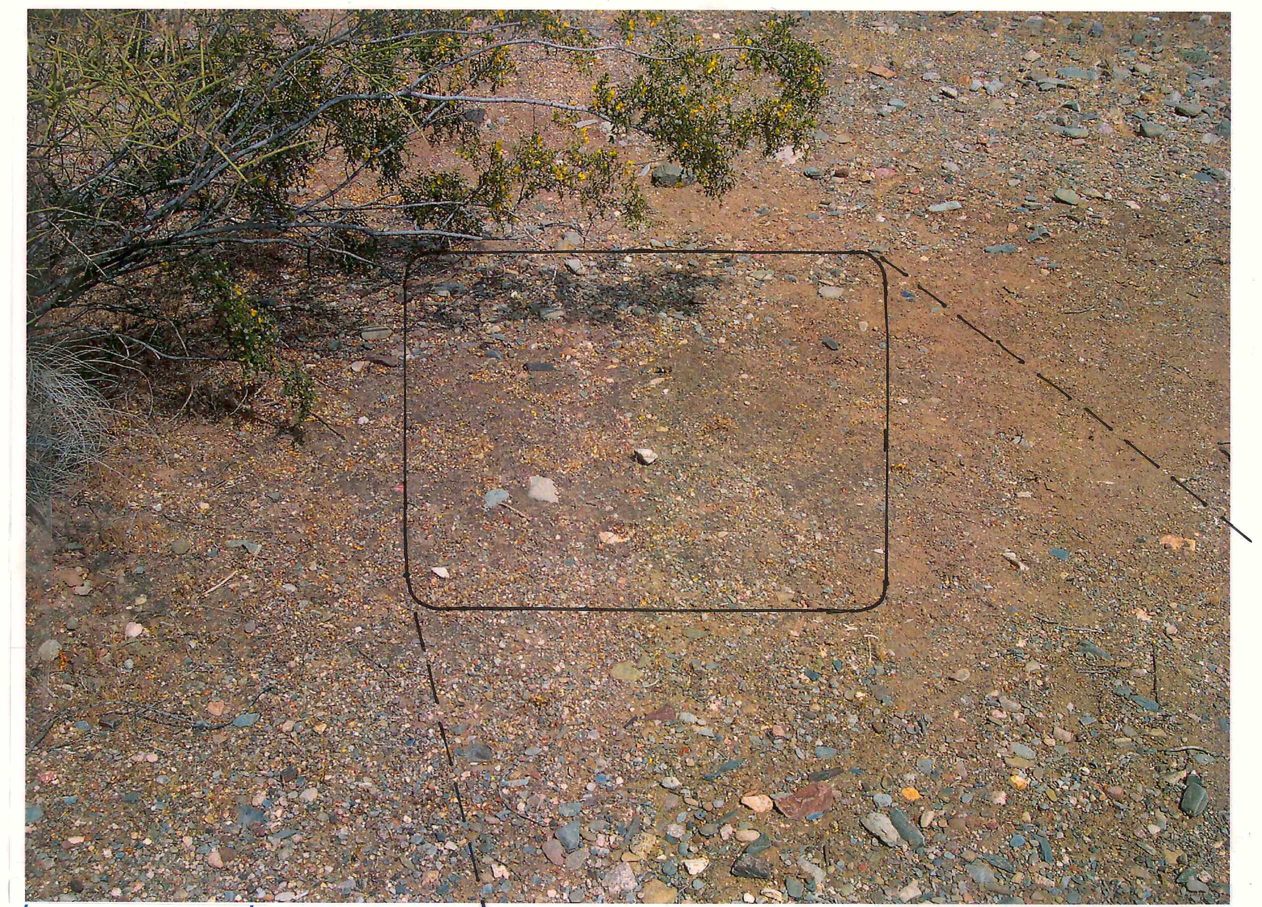

FIGURE 5-A
LOCATION 5
LOOKING SOUTH

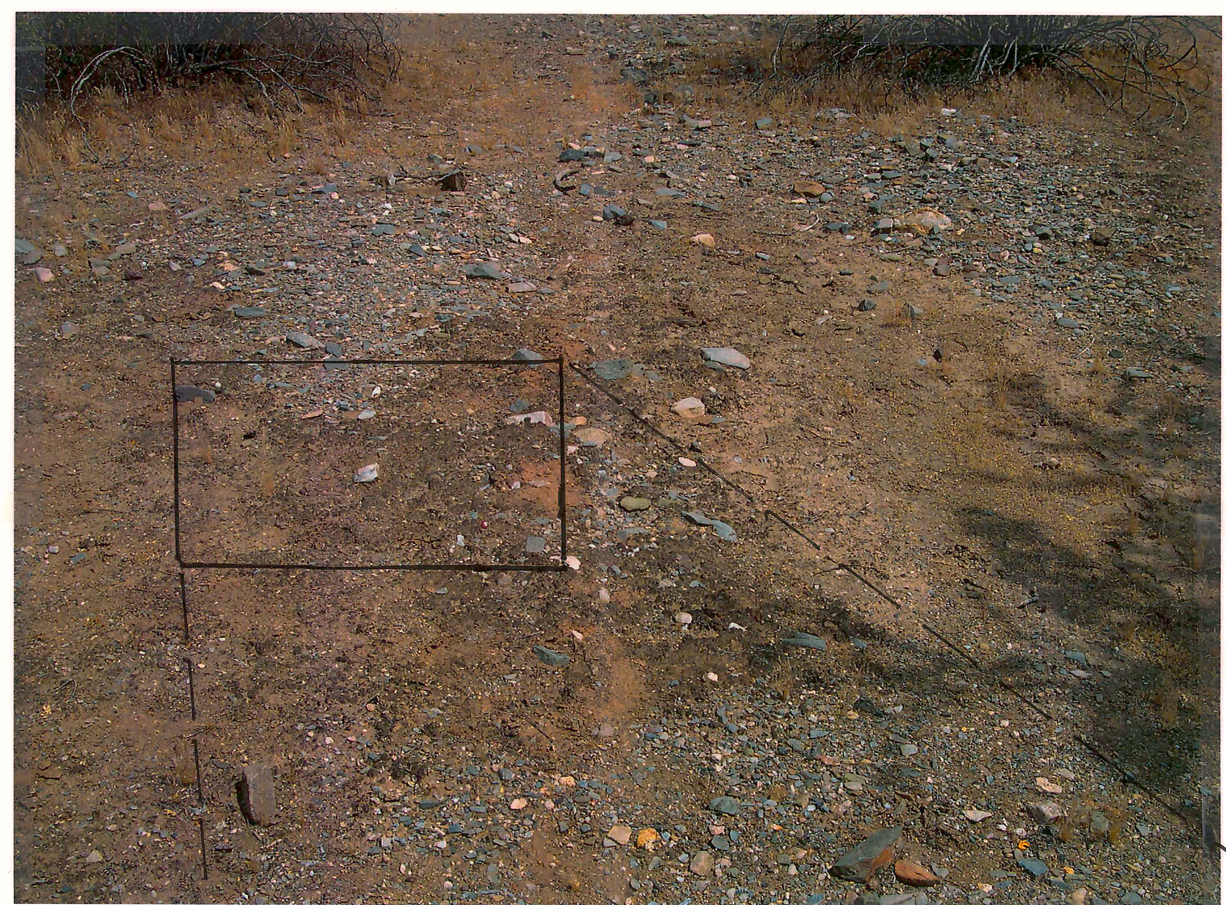

FIGURE 5-C
LOCATION 5
LOOKING SOUTH

FIGURE 5-B
CLOSE-UP
OF FIG. 5-A

FIGURE 5-D
CLOSE-UP
OF FIG. 5-C

FIGURE 6
LOCATION 6
LOOKING SOUTH

PADELFORD WASH FLOODPLAIN DELINEATION STUDY
GROUND PHOTOS AT LOWER PORTION OF STUDY

SHEET 2 OF 4

FIGURE 7-A
LOCATION 7
LOOKING SOUTHEAST

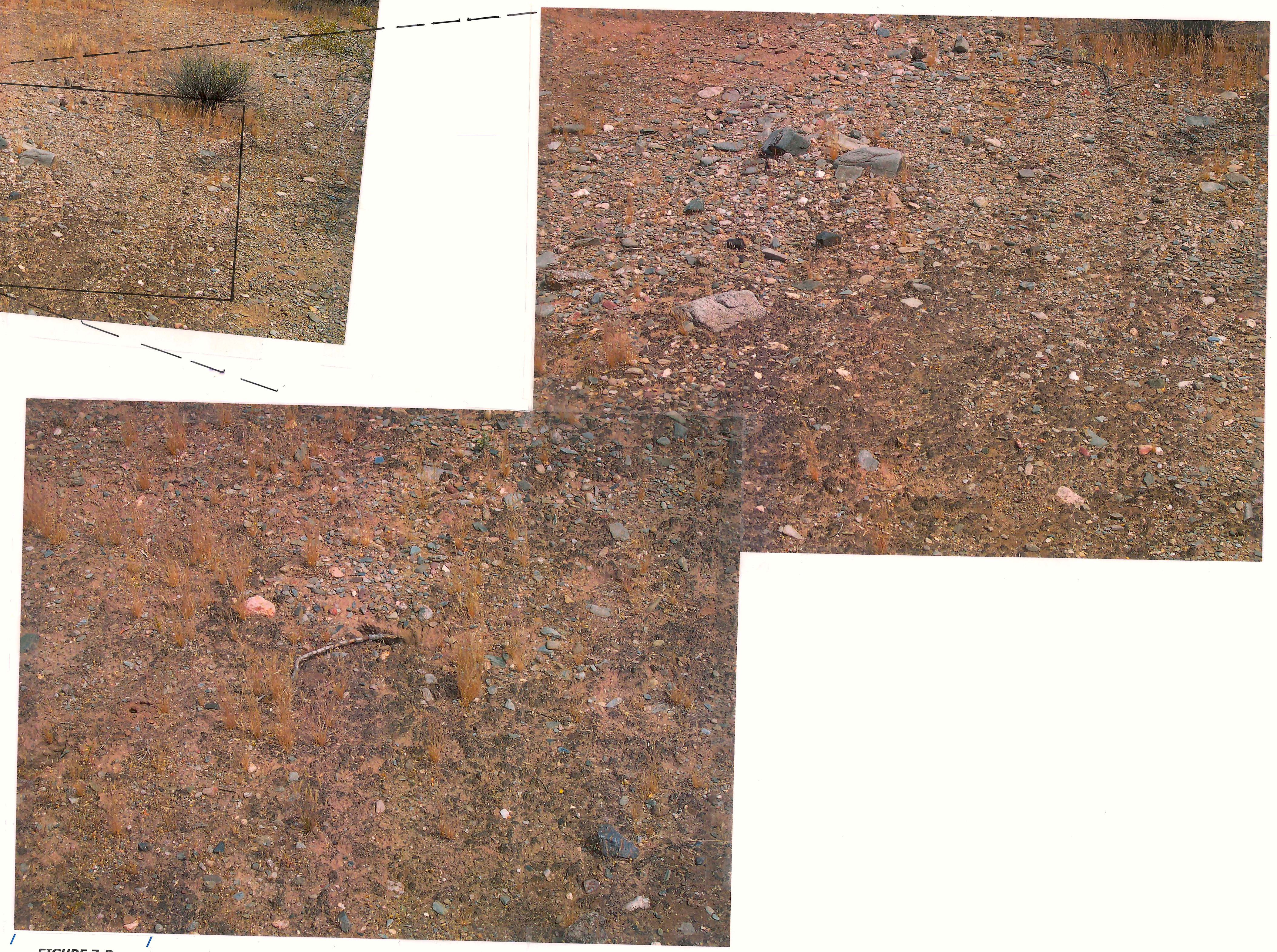

FIGURE 7-B
CLOSE-UP
OF FIG. 7-A

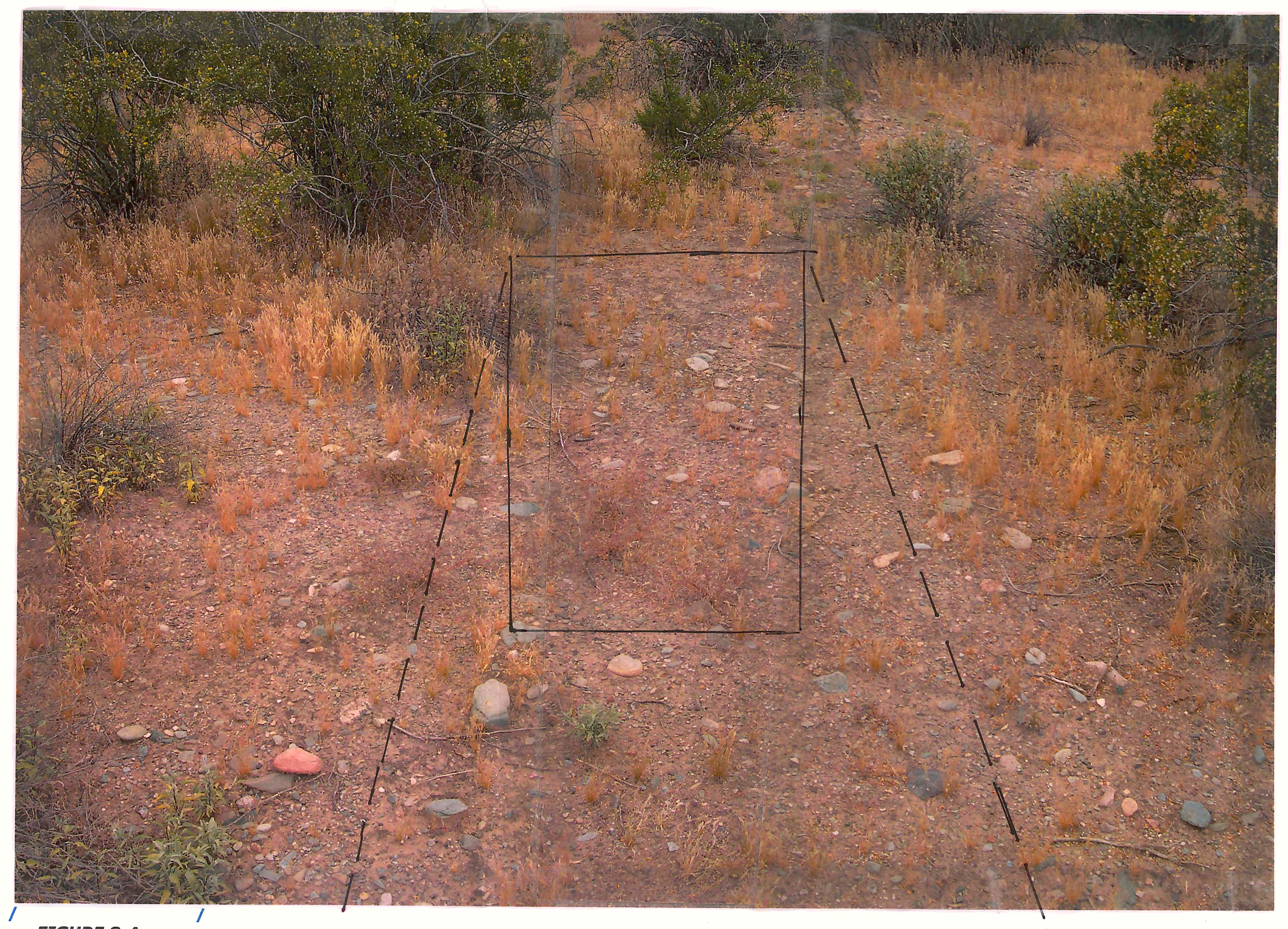

FIGURE 8-A
LOCATION 8
LOOKING SOUTH

FIGURE 8-B
CLOSE-UP
OF FIG. 8-A

FIGURE 9
LOCATION 9
LOOKING SOUTH

PADELFORD WASH FLOODPLAIN DELINEATION STUDY
GROUND PHOTOS AT LOWER PORTION OF STUDY

SHEET 3 OF 4

Page 40 of Padelford Wash F.D.S. - Inactive Fan Documentation Was sheet 4 of 4 was unable to be scanned please see originals.

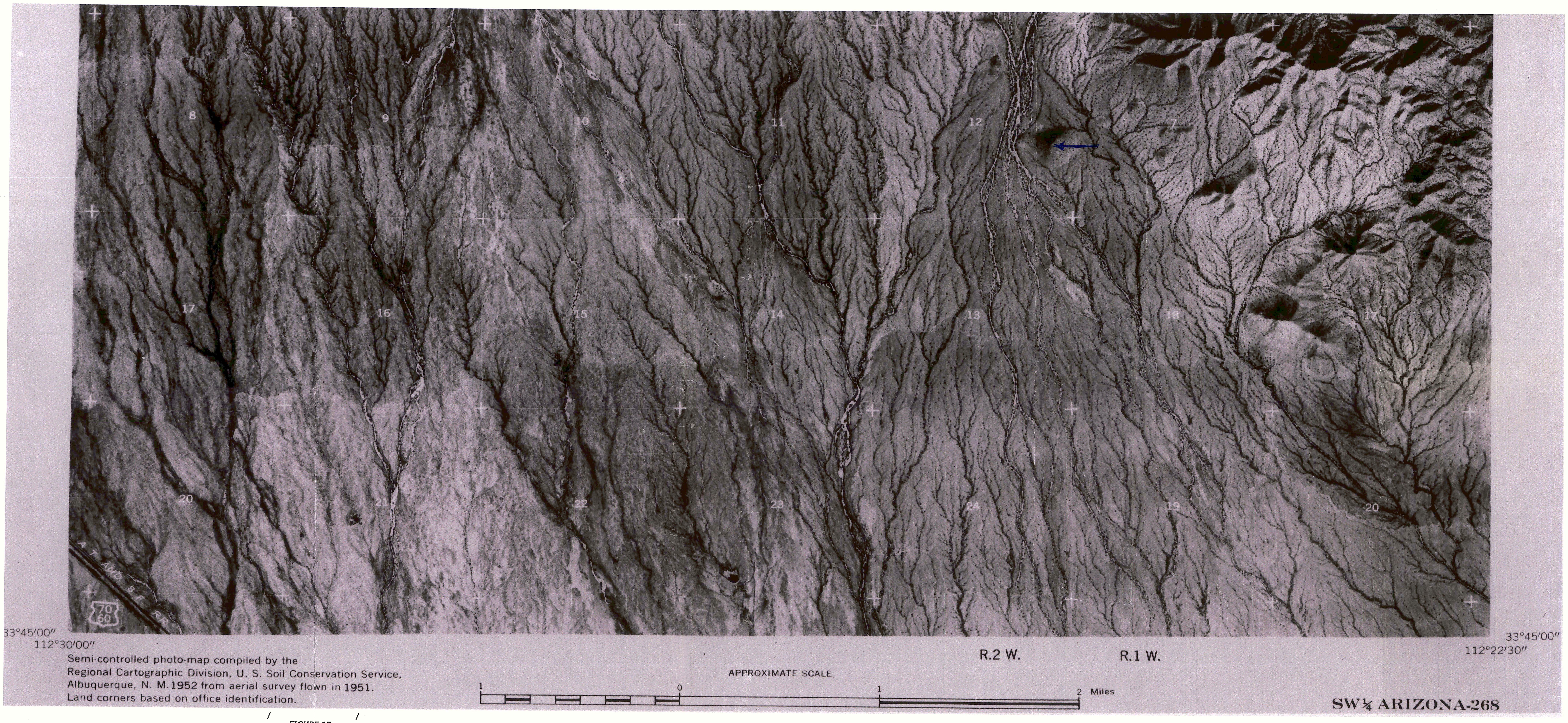

FIGURE 15
1951 AERIAL PHOTO

FIGURE 14
LOCATION 14
LOOKING SOUTH

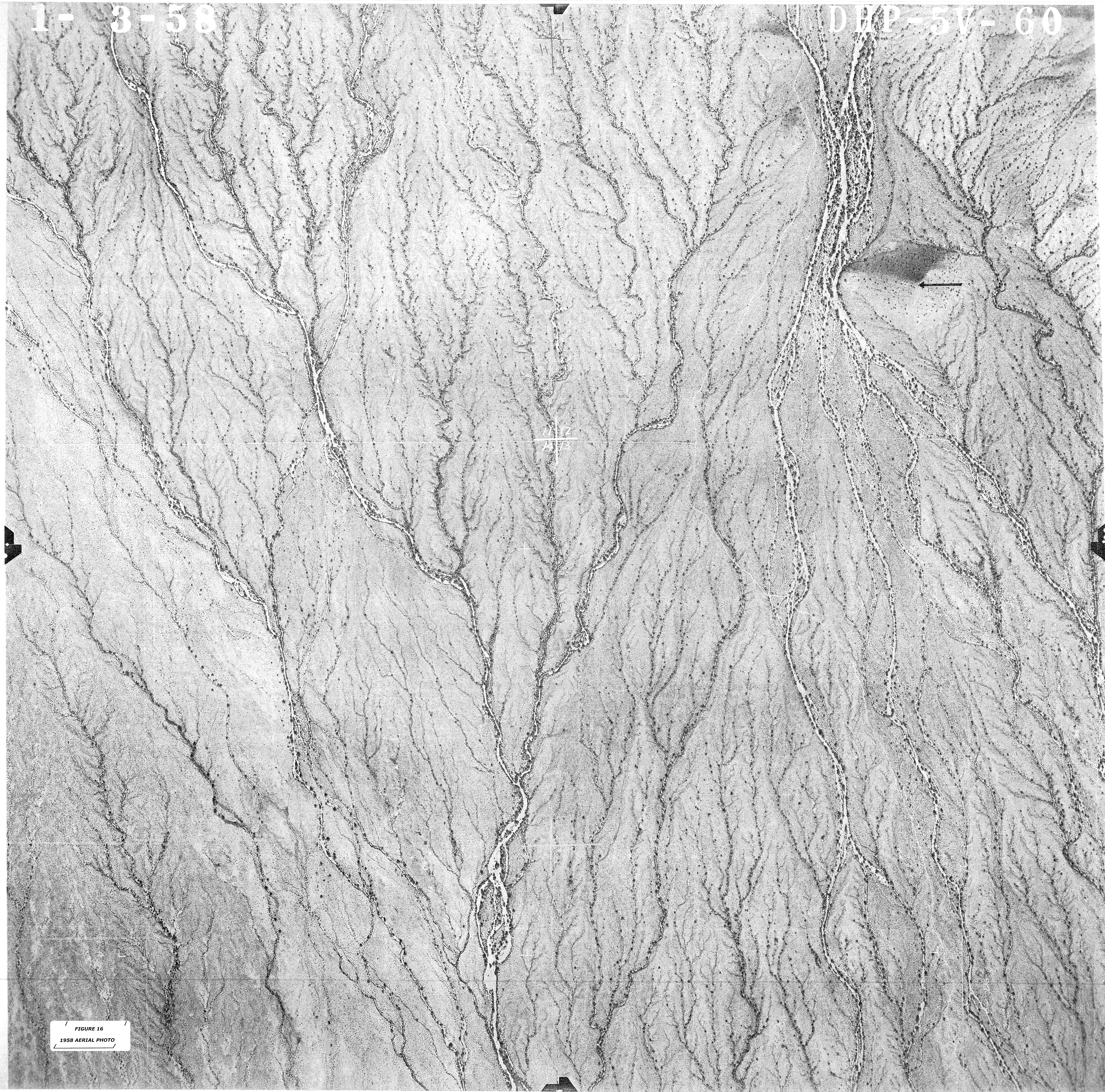

FIGURE 16

1958 AERIAL PHOTO