RECONNAISSANCE ASSESSMENT OF QUATERNARY FAULTING IN THE GILA REGION FROM SAN CARLOS RESERVOIR TO COOLIDGE ARIZONA

by
Robert B. Scarborough and Philip A. Pearthree

Open-File Report 88-15

1988

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

Prepared for:
United States Department of the Interior
Bureau of Reclamation Engineering and Research Center
Seisimotectonic Section

INTRODUCTION

This report summarizes a search for evidence of Quaternary faulting along the Gila River in central Arizona. The region covered in this analysis extends about 40 km north and south of the Gila River between 110° and 111° 30' W longitude (Figure 1). The goal of this study has been to delineate any possible Quaternary faults in the area surrounding existing and potential dam sites on the Gila River. The study consisted of systematic interpretation of aerial photography to locate possible Quaternary faults, helicopter overflight of the most suspicious features, and brief field reconnaissance of some of the features. Based on this analysis, features were classified as being either possible Quaternary faults or unlikely to be Quaternary faults.

Previous Work

Potential earthquake hazard in central Arizona has been addressed in several previous reports. Historical seismicity in Arizona from about 1900 through 1980 was summarized by DuBois and others (1982). Modified Mercalli intensity maps of the larger historic earthquakes in central Arizona (Figure 2) show that the region has been subject to MM intensities of up to VI. Geologic studies of Quaternary faulting in Arizona include a state-wide reconnaissance analysis (Menges and Pearthree, 1983; Pearthree and others, 1983) and reports on possible Quaternary faults around U.S. Bureau of Reclamation dam sites in central Arizona (Fugro, 1981; Pearthree and Scarborough, 1984). These studies provide a background from which to proceed with the present analysis.

Regional Neotectonic Setting

Studies of Quaternary faulting and historical seismicity in Arizona cited above have defined the general seismotectonic setting of the Gila River region in central Arizona. The region studied for this report was subjected to extensive late Tertiary normal faulting of the Basin-Range disturbance. This disturbance, which evidently began between 10-13 Ma in the southern Basin and Range and Transition Zone physiographic provinces, resulted in the formation of most of the present structural basins in southern and central Arizona (Eberly and Stanley, 1978; Scarborough and Peirce, 1978; Shafiqullah and others, 1980). Landforms indicative of tectonic inactivity dominate this region today, implying that major normal faulting ceased in most areas during the late Miocene or Pliocene (Shafiqullah and others, 1980; Menges and McFadden, 1981). This conclusion is consistent with the very low levels of historic seismicity and sparse evidence for Quaternary faulting in

southern and central Arizona.

METHODS

The methods utilized in this study were the same as reported by Pearthree and Scarborough (1984) for a parallel study covering the central part of the Arizona. The three phases of this study were 1) stereoscopic examination of 1:58,000 scale color infrared aerial photographs, 2) helicopter overflight of the most suspicious features, and 3) a brief field reconnaissance examination of some of the features. The aerial photographs were taken in 1981 as part of the National High Altitude Photography (NHAP) program.

Possible Quaternary faults were identified by examining the color IR photographs. As noted in Pearthree and Scarborough (1984), scarp features with vertical relief more than one or two meters and length greater than a few hundred meters may usually be seen on these photographs, especially if vegetative lineaments accompany the features.

Target features were grouped into two categories based on the likelihood that they represent Quaternary faulting. The category of possible Quaternary faults includes features that may be the result of Quaternary faulting, but with a distinct possibility that they are of nontectonic origin. Some features of this category are demonstrable faults for which no certain evidence of displacement of Quaternary deposits was found. Other features are located in settings where Quaternary deposits are sparse or poorly preserved, so the potential record of Quaternary faulting is poor.

The second category is comprised of lineaments or geomorphic features for which no evidence of Quaternary faulting was discovered. This includes lineaments on alluvial surfaces with no relief across them, bedrock escarpments and bedrock-alluvium contacts with no evidence of displacement of Quaternary deposits that cross them, alluvial scarps likely created by fluvial erosion, and intrabedrock dikes where more resistant lithologies are responsible for scarp-like relief.

Preservation of Quaternary deposits is critical in identifying Quaternary faults in the Transition Zone of east-central Arizona, where long-term regional base-level fall has resulted in extensive dissection of basin and bedrock areas. The local intensity of dissection and particle-size of Quaternary deposits dictate whether well-preserved suites of terraces have formed, or ridge and ravine topography has developed with few planar surfaces preserved. A different problem is presented by the low-relief alluvial plains common in the western portion of the study area, where an often-complex mosaic of small

vegetated stream courses crosses the area, tending to mask any possible tectonic scarps.

The ability to recognize Quaternary faulting in central Arizona is extremely variable because of this variety of physiographic settings. Evidence of individual fault displacement events of one meter or more might be preserved for 10,000-20,000 years to 100,000+ years depending on the local setting. Recognition of individual faulting events is therefore restricted to about the last 100,000 years, and locally to a much shorter interval.

DESCRIPTION OF INDIVIDUAL FEATURES

The features discussed below are the only ones recognized on the photographs as representing potential Quaternary faults. They are numbered 1-13 in this listing and are approximately located on Figure 1. A geographic description with the appropriate 7.5' quadrangle for each feature is included in the listings. Also listed on Figure 1 is the NHAP photograph number on which the feature is approximately centered.

Possible Quaternary Faults

(1) West of Picketpost Mountain
(S 1/2 sec 10 and west central part of sec 11, T2S, R11E; Picketpost Mtn, AZ 7.5')

A photolinear was noted that trends generally ENE, subparallel to and just south of Highway 60, 4 km west of Picketpost Mtn. The feature is sharply defined on the photographs, and is represented along its eastern half as the northward truncation of a series of 5 to 10 m-high north-trending spurs of basin fill gravels, and along its western half by a series of vegetated alined rills and minor drainages. The feature extends for 2.5 km, from near the crest of hill 2815 on the west to very near the center of section 11 on the east.

In the field, the feature was noted to be one of several ENE-trending faults that cut a terrain of Precambrian Pinal Schist and diorite. Erosion of the hills has produced a series of alined benches on the hillslopes in southern sec 10. However, the northward truncation of the basin fill spurs is due to a more obscure reason, possibly late Tertiary faulting. It is not obvious that the spurs are truncated by recent erosion along a drainage, as present drainages in the area trend more northeasterly than the line of truncation of the spurs. A cautionary note may be added here that the line of truncated spurs resembles the features along the southern extent of the Sugarloaf fault, which is regarded by Pearthree and Scarborough

(1984) as a probable Quaternary fault, at least along its northern extent. However, no definitive evidence was noted for Quaternary faulting along feature (1).

(2) South side of Gila River, near China Wash (secs 24, 26, 27, 34, T4S, R10E; Florence SE, AZ 7.5')

This photolinear feature consists of the southeast edge of a long narrow zone of elevated terrace remnants with accordant crests, sitting above an alluvial piedmont slope just south of the Gila River (Figure 3). The terrace remnants trend NE; a series of NW-trending streams are incised through the terrace remnants.

The accordant ridge crests are mantled with a lag gravel that consists of 5-100 mm diameter well-rounded clasts (average 10-20 mm) of resistant rock types, including quartzites, schists, and volcanics. We interpret the deposit as a lag concentrate of river gravel beds, probably from the ancient Gila River. Piedmont gravels derived from the southeast contact the zone of elevated ridges to the southeast of the linear zone of interest here. There is 2-3 m of relief (lag gravel side high) across the boundary. The piedmont deposits are a coarse grained grussy gravel that contains small chunks of laminar caliche and occasional pebbles of locally derived resistant volcanic rocks, but lack the diverse rock types found in the lag gravels. The presence of the caliche indicates a relict soil is being degraded, either in situ or somewhere farther up the piedmont slope. Fairly recent silt deposition has occurred along some stream courses just upslope of the interface.

About 30 m of Gila River gravels cap an 8.9 Ma basalt flow at China Wash (near center sec 13, T4S, R10E; Shafiqullah and others, 1980), along the trend of the elevated ridge zone to the northeast. Therefore, the possibility exists that the lag gravel-capped remnants represent an abandoned reach of the Gila River that flowed over the basalt flow at China Wash, later became isolated by a northward meander of the river, and eventually formed a gravel-capped terrace that became topographically inverted when the Gila River began downcutting. The streams dissecting the lag deposit must have been antecedent to the lag deposit. Denudation of the piedmont gravels has probably been faster than the lag gravel-capped terrace, such that their interface has developed 2-3 m of relief. This scenario of scarp formation due to differential erodibility of Gila River gravels and piedmont gravels is preferred, but a tectonic origin for the scarp cannot be ruled out based on our work.

(3) Antelope Flat, between Hackberry Wash and Hackberry Draw (from 110°, 19' W, 33°, 20'N, to 110° 18'W, 33° 22'N; Mount Triplett 7 1/2' quad)

Two N- to NW-trending scarps cut a well-preserved and therefore probably fairly young basalt flow. Scarps are distinctly visible on aerial photos, but are locally quite irregular in trend and appear to splay at the northern end of the features. The southern limit of the feature occurs at the margin of the basalt flow near Hackberry Spring. Southwest of this point, the feature would follow the valley of Hackberry Draw; no lineation is clearly apparent there. No published radiometric dates are available for the Antelope Flat basalt flow; a date of 0.93 + 0.08 Ma has been determined for the Peridote Mesa flow (Shafiqullah and others, 1980), located about 5 km to the west. The Peridote Mesa flow appears somewhat darker on the aerial photos, suggesting that it is younger than the Antelope Flat flow.

The scarps cutting across the Antelope flow are probably either fault-generated or are margins of thin basalt flows. Aerial reconnaissance of the southwestern limit of the features (where the scarp intersects the edge of the basalt flow near Hackberry Spring) revealed possible offset of the resistant uppermost portion of the basalt flow. This resistant layer appeared to be fairly abruptly truncated at the scarp, and no evidence was observed of the rather jumbled morphology that often characterizes flow margins. Further onsite analysis at this site might reveal the presence or absence of a fault zone associated with the scarp, and a radiometric date on the flow would give a maximum age of faulting.

Other Features Investigated that are Unlikely to be Quaternary Faults

(4) Superstition Wilderness, area of Peralta trailhead (central secs. 27, 28, T1N, R10E; Weavers Needle, AZ 7.5')

Two photolinear features were noted in a low relief area near the Peralta trailhead and south of Miner's Needle, east of the town of Apache Junction. The Precambrian granite which underlies this area may represent the core of an E-W trending anticline. The photolinear features stand out as vegetation lineaments, and trend generally east-west. Inspection on the ground failed to reveal any scarps associated with these features. They most likely consist of older fault lines cutting the Precambrian rocks, along which groundwater reaches the surface as a series of ephemeral seeps. Native willow trees, mesquites, and acacia trees have prospered there because of the springs. A 1-4 m-thick layer of somewhat dissected cobbly alluvium of probable late Pleistocene age covers the pedimented granite in most areas, and would be a sensitive recorder of late Quaternary faulting. Several low fluvial terrace scarps cut into this alluvium along minor drainages were noted in the area. None of these were

parallel to the photolinear trends.

(5) North of Picketpost Mountain
(NE 1/4 sec 21 and adjacent SE part sec 16, T1S, R12E; Picketpost Mtn, AZ 7.5')

A vegetative lineament that parallels a stretch of Whitford Canyon, 200-300 m east of the stream, was examined from the air. The area consists of tectonically tilted eastward dipping Tertiary volcanics, just upstream of an area where bedrock is buried under highly dissected basin fill. The feature investigated is a fault that appears to place volcanics against Precambrian granite and diabase. The fault trends ENE, parallel to the strike of the rotated volcanics, and so is probably a Miocene-aged normal fault, with no evidence of young movement. The fault line in part occupies a steepened hillslope segment that appears to be weathered diabase, perhaps a dike, conducive to the growth of juniper trees that help to define the fault line on the photographs.

(6) South of Superior
(SE 1/4 sec 10 and W 1/2 sec 11, T2S, R12E; Superior, AZ 7.5')

Two linear features were noted here. The first consists of a subtle linear vegetation alinement across a 50 m-wide terrace remnant in SE 1/4 SE 1/4 sec 10. Farther north, across Highway 177, a roughly parallel alinement consists, upon aerial inspection, of the interface of a west-facing hillslope and the upper terminus of a light gray-colored terrace. No evidence of faulting of Quaternary deposits was noted in either of the areas. The photolinear feature in the first area is defined by two alined shallow gullies draining in opposite directions off the terrace remnant.

(7) Basin and Range fault near Mineral Mountain
(E 1/2 of secs 7, 18, 19, 30, T3S, R11E; Florence NE, AZ 7.5')

A basin and range fault that trends nearly exactly N-S with an overall length of 5 km is located 1.5 km west of Mineral Mtn. Aerial reconnaissance along the southern part of the fault failed to note any evidence for Quaternary faulting in this reach. Basin fill was noted to overlap a pediment cut on rocks of the Pinal Schist terrain in this area. Along the center of the E 1/2 of section 30, a stream has downcut along the interface of the basin fill sediments and the schists. No scarps were noted on the terrace surface above the trace of the fault in the S 1/2 of the NE 1/4 of section 30. Farther north in sections 18 and 19 small hills made of resistant rock types have remnant masses of basin fill preserved on their western flanks. Differential erosion has cut gullies, notches, and saddles along the contact, and intensified its visibility in the photographs.

(8) Alluvial plains north of Florence
(20 entire townships, outlined in Figure 1,specific features noted in secs 11 and 14, 16 and 21, 20, and 30, T3S, R10E; Florence NE, AZ 7.5')

A large area noted on Figure 1 consists of a gently sloping alluvial plain with drainages that head in the southern Superstition Mountains and unnamed hills south of Picketpost Mtn, and essentially terminate along the NE flank of the Santan Mts. The major drainage that exits the area is Queen Creek, which drains the region above Superior. It is artificially channelized in its lower reaches until it joins the Santan canal north of the town of Sacaton. Hundreds of minor ephemeral stream segments on the plains are visible on the photographs, some of which are discontinuous, each made very visible on the photographs by accompanying vegetation.

Stereoscopic examination of the region disclosed many areas where certain stream alinements were nonparallel to the local average direction. Aerial examination of a number of features whose coordinates are listed above failed to disclose any evidence of surface ruptures in this particular area. Many of the anomalous lineaments appear to be due to old roadways or cattle tracks, many of which are alined SSW, at an angle to the SW alinement of drainages in the area. As well, a recent episode of arroyo cutting is obviously ongoing in parts of the area. If Quaternary faults were present on the plains, they might not be easily seen on the photographs if they had minor offset, because of the high visibility of the numerous dark-colored drainage paths against the light-colored soil surface. Low sun-angle photography of the plains could potentially make more subtle surface features relatively more visible. Laney and others (1978) indicate several areas in the Mesa-Apache Junction and the Chandler Heights areas in which earth fissures had developed pre-1978. They show no similar features farther southeast.

(9) North side of Gila River (E central sec 10, W central sec 11, T4S, R10E; Florence SE, AZ 7.5')

A visible lineation was noted on a low terrace on the north side of the Gila River, about 10 km upstream from Florence. The feature is defined both by a narrow discontinuous band of light color and a line of vegetation. Surface examination of the feature indicated it is of nontectonic origin, being related to the location of light-colored soil remnants and associated vegetation near the toe of a higher fluvial terrace scarp.

(10) North of Grayback Peak (southern parts secs 1,2; northern parts secs 11,12, T4S, R12E; Grayback, AZ 7.5')

Based on aerial examination of four scarp-like features parallel to and just south of the Gila River, two miles NE of

Grayback Peak, it was concluded that they are a series of light-colored dikes cutting the granite terrain. In this area, a pediment has been cut on the granite. The dikes stand up with relief above the granite partially because they are more resistant, and partially in response to the last phase of about 5-10 m of Gila River entrenchment below the pediment level.

(11) South of Gibson Wash
(located north of U.S. 70, south of pipeline road, between 110° 31' and 110° 36' W longitude)

Lineations and broad color banding trend roughly E-W across the piedmont south of Gibson Wash. An indistinct lineation continues into probable Quaternary deposits. A sharper lineation or scarp truncates basalt at eastern end of feature. Aerial overflight of feature revealed that the lineation trending across alluvial fan deposits is not associated with a recognizable scarp, and the scarp truncating the basalt outcrop is probably the result of fluvial erosion.

(12) Hollywood Bowl (southeast of Hollywood Bowl tank, between Apache Wash and Hackberry Draw; San Carlos Reservoir 15', San Carlos 7 1/2' quads)

A very indistinct and discontinuous series of lineations trending across fine-grained basin fill(?) deposits. Some younger Quaternary deposits are clearly not displaced. Lineations are roughly associated with a high topographic scarp. Aerial reconnaissance did not reveal any distinct topographic breaks associated with the lineations.

(13) East of Chittakow Draw
(from 110° 10'W, 33° 8'N to 110° 23' W, 33° 8'N; Bates Draw to Chittakow Draw; Bylas and San Carlos Reservoir 15' quads)

A prominent, high, discontinuous topographic escarpment parallels the south edge of San Carlos Reservoir, about 3 km south of the shore. Quaternary deposits that appear to be of some antiquity crosscut the escarpment in several locations. There are no sharp lineations or scarps associated with this feature. If the feature is fault-generated, there has most likely been no late Quaternary movement. Equally likely, the scarp could have been cut by the Gila River sometime in the middle or early Quaternary. The Gila has subsequently continued to downcut and has migrated several kilometers to the north.

CONCLUSIONS

No features were found in the study area that were identified as probable Quaternary faults, but several features are possible Quaternary faults and could bear further

investigation. The general paucity of evidence for Quaternary faulting in this region suggests that 1) few faults have been active during the Quaternary, and 2) if faults have been active during the Quaternary, slip rates have been very low.

REFERENCES

DuBois, S.M., Smith, A.W., Nye, N.K., Nowak, T.A., 1982, Arizona Earthquakes, 1776-1980. Arizona Bureau of Geology and Mineral Technology Bulletin 193, 456 p.

Laney, R.L., Raymond, R.H., and Winikka, C.C., 1978, Map showing water-level declines, land subsidence, and earth fissures in south-central Arizona. U.S. Geological Survey Water Resources Investigations 78-83 open-file report; 2 sheets, scale about 1:125,000.

Menges, C.M., McFadden, L.D., 1981, Evidence for a latest Miocene to Pliocene transition from Basin-Range tectonic to post-tectonic landscape in southeastern Arizona: Ariz. Geol. Soc. Digest, v. 13, p. 151-160.

Menges, C.M., Pearthree, P.A., 1983, Map of Neotectonic deformation in Arizona: Ariz. Bur. Geol. Min. Tech. Open-file Report 83-22, 1:500,000 scale, 2 sheets.

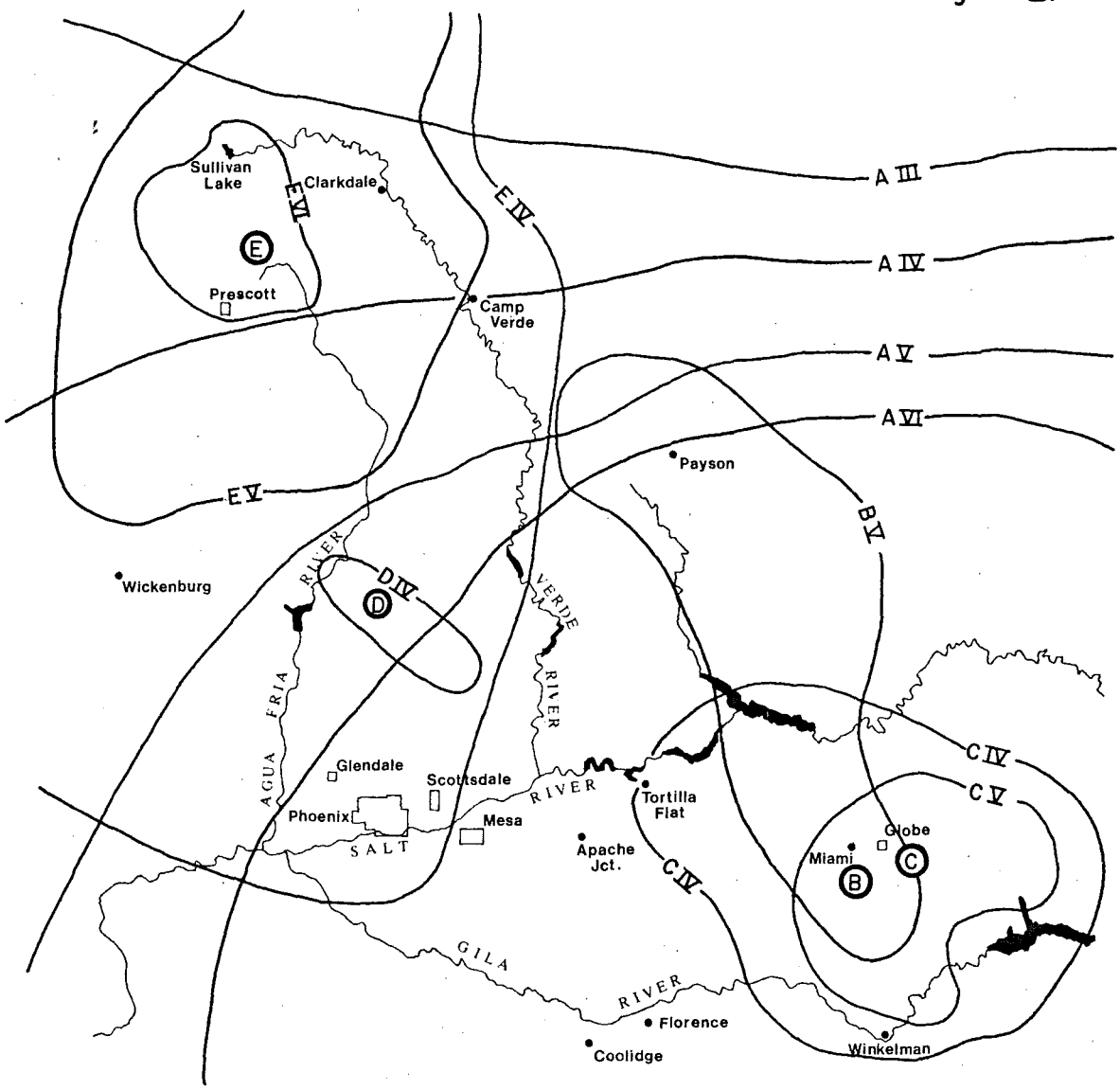
Pearthree, P.A., Menges, C.M., Mayer, Larry, 1983, Distribution, recurrence, and possible tectonic implications of late Quaternary faulting in Arizona: Ariz. Bur. Geol. Min. Tech. Open-file Report 83-20, 50 p.

Pearthree, P.M. and Scarborough, R.B., 1984, Reconnaissance analysis of possible Quaternary faulting in central Arizona: Arizona Bureau of Geology and Mineral Technology open-file report 84-7. 27 p.

Scarborough, R.B., Peirce, H.W., 1978, Late Cenozoic basins of Arizona, in Callender, J.F., Wilt, J.C., Clemons, R.E., eds., Land of Cochise: New Mexico Geological Soc. Guidebook 29, p. 253-259.

Shafiqullah, M., and others (1980) K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas. Arizona Geological Society Digest, v. 12, p. 201-260.

Figure 2.



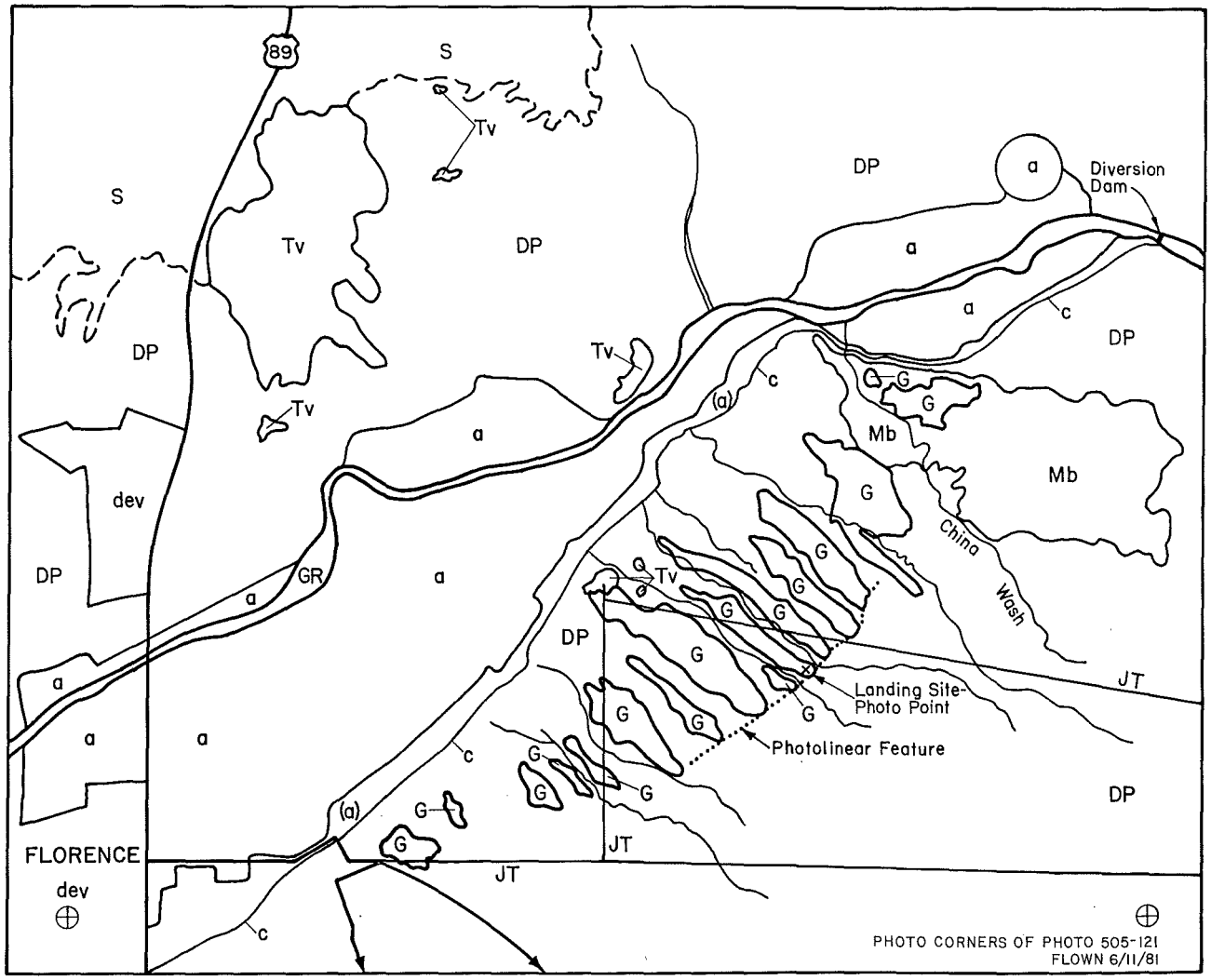
O Epicenters

-BV- Line of equal modified Mercalli Intensity.

A. 3 May 1887, Sonora, Mexico Mag. 7.25 at epicenter, Int. VI in Phoenix.
B. 17 June 1922, Miami, Arizona Int. VI.
C. 11 Sept. 1963, Globe, Arizona Int. VI, Mag. 4.1.
D. 24 Dec. 1974, Cave Creek, Arizona Int. V, ML 3.0.
E. 4 Feb. 1976, Chino Valley, Arizona Int. VI, Mb 4.9-5.2.

Contoured Modified Mercalli Intensity Maps of Selected Historic Earthquakes Felt in Central Arizona.

Data from Dubois and others (1982) and Sauck (1976).
This map drawn by Scarborough, 8/84.



GEOLOGY

G Gila River gravels atop Mb (Lag gravels)

Mb Late Miocene basalt flow (8.9 m.y.)

Tv Tertiary volcanics (30-15 m.y.)

GR active channel of Gila River

S remnant high-level surface with thick relict Cca horizon

DP dissected basin fill terrain (Piedmont gravels in discussion)

CULTURAL FEATURES

a floodplain - agricultural

dev developed - housing

c diversion canal

JT jeep trail

(a) undeveloped floodplain

mi. 0 1 2

km. 0 1 2 3

SCALE 1:58,000 (SAME AS NHAP PHOTOS)

Figure 3. GEOLOGIC MAP OF *FEATURE* (2); area identified on Figure 1.

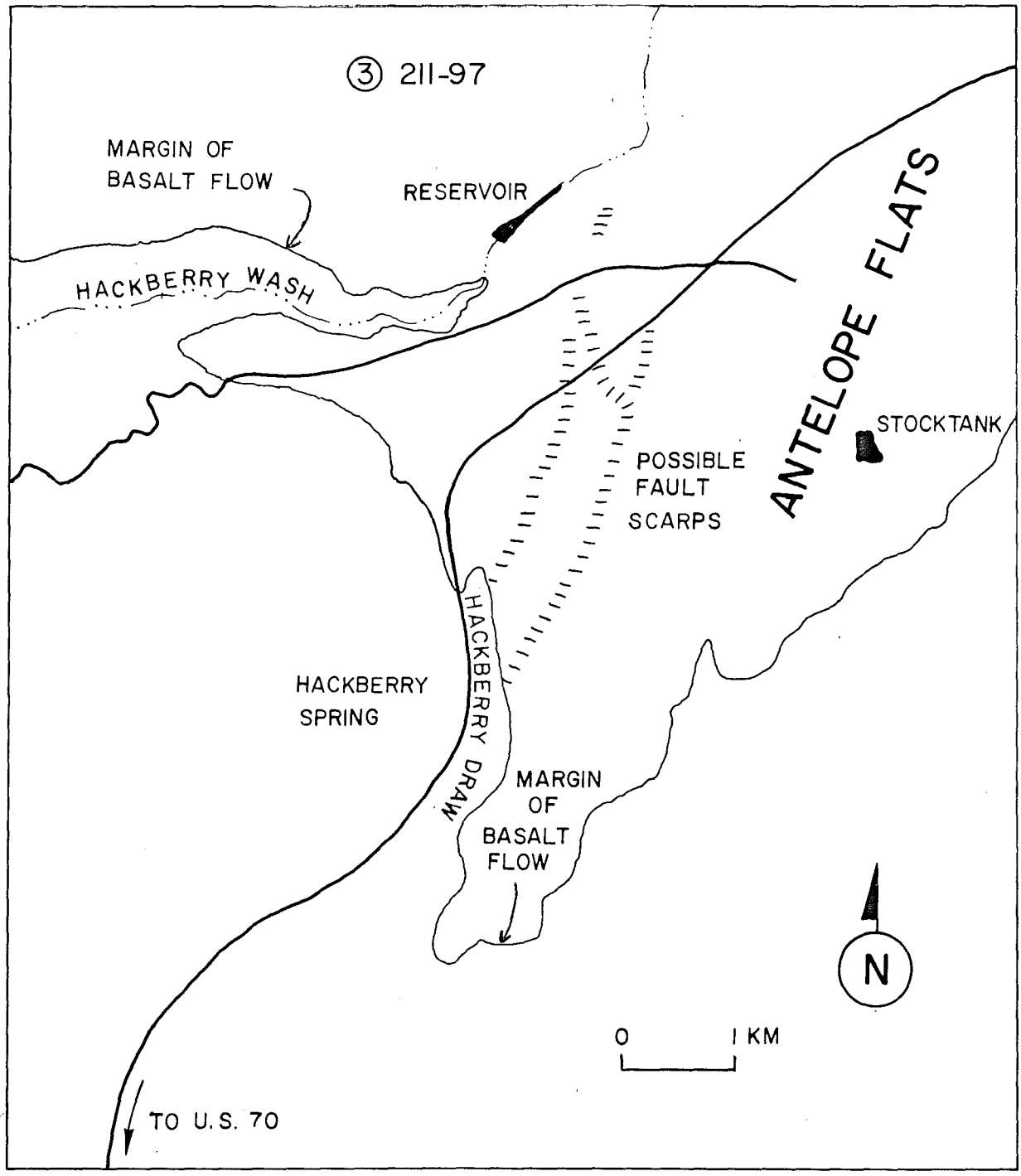


Figure 4. SKETCH MAP OF FEATURE 3.
Scarps occur on Plio-Quaternary (?) age basalt flow.