LOST PERENNIAL RIPARIAN HABITATS OF THE SOUTHEAST SIERRITAS: STRUCTURAL RELATIONS AND THE 1887 EARTHQUAKE

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Introduction

The area of study is about 30 miles south of Tucson, Arizona in the southeastern quadrant of the Sierrita Mountains, mostly within the Twin Buttes 7.5 minute quadrangle.

A previous study (Zauderer, 1989) presented some of the basin characteristics for Batamote and Proctor washes wthin the study area, and the evidences for considering them as lost perennial mesquite bosque habitats in the lower elevations, below 4000 feet. Such evidence includes: a) the morphology of abandoned channels in silty tuffaceous alluvium, b) the creation of newer high energy erosive channels resulting from increased lateral inputs from denuded slopes, c) lines of tree stumps on higher terrace surfaces where de-watering of the perched water table killed the established older perennial canopy, d) black/dark brown organic A horizon soils on lower floodplain surfaces extending into Sopori Wash flooodplain silts, including cienega soil lenses, and e) the underlying geologic control of the wash system that provides the perching mechanism common to other perennial habitats in the periferal Santa Cruz system. A barrier to discharge losses, however, is not present.

When the Santa Cruz began a century of hydraulic readjustment, the Sopori Wash and lateral perched perennial habitats were drained and experienced erosional entrenchment through the former riparian floodplains. This episode of regional hydraulic readjustment seems to presently impinge upon existing perennial and cienega habitats perched above the main trunk of the drainage. Based on the late Tertiary and Quaternary geology of the area, and the hydrogeologic history of the Tucson basin, the present epeisode of hydraulic adjustment may be a visible result of a broad, long term incremental processes of the region's structural dynamics.

This presentation examines the relation of underlying structure, structural control, and hydro-ecology in the study area to the 1887 earthquake, and draws some arm-waving conclusions about riparian and cienega management.

Figure 1 shows the extent and interpreted power of the May 3rd,1887 Bavispe earthquake (after Dubois and Smith, 1980).

Betancourt (1986) found an interesting observation of the effect of the earthquake on tributary discharge into the Santa Cruz: "From his ranch in the Sierrita Mountains, Hiram Stevens reported that the earthquake more than doubled the flow of nearby streams" (in the Arizona Daily Star, June 2, 1888). The rainfall in may of that year was under 2 centimeters. This powerful earthquake (estimated at 7.2 at Tucson, on a modified Mercali Intensity Value scale by Dubois and Smith, 1980) affected spring and stream flow in southern Arizona (Dubois and Smith, 1980). In the area of this study, the compression wave could have affected stream flow by de-watering the confined saturated sediments contained within the high-seismic velocity upper-Tertiary tuffaceous conglomerate. Another mechanism of system de-watering and erosion could have been caused by the disturbance of floodplain depositional-erosional balance at several bottle-neck sites along the stream profile. These bottle-necks are associated with surface lineament expressions, vertical displacement faults, and formation contacts.

Results and Discussion

Figure 2 shows the surface topography of the study area below 4200 feet elevation. Several NW-SE trending lineaments seem to be related to middle-Pleistocene scouring of the underlying tuffaceous conglomerate. The parallel NE-SW trending lineaments relate to erosional surfaces on the tertiary bedrock, and parallel or coincide with vertical displacement faults. Also on figure 2 are lines of section, X-X' and Y-Y' for figure 4.

Figure 3 shows the surface geology for the area in figure 2. The _.._ line delineates the extent of holocene floodplain deposits derived from tuffaceous conglomeratic sources. (data from field work, and Cooper, 1960, 1973; Drewes, 1980; Kelly 1977; and Smith,1966).

Figure 4 shows the crossections X-X' and Y-Y' indicated on figure 2. Of interest is the successive nesting of late Tertiary to recent fluviatile deposts. The inner holocene floodplain (2400fps) probably lies directly on top of the 6600 fps layer. This is inferred from the seismic data (Sternberg, 1987), and the field mapping of resistant layers in the upper tuffaceous conglomerate (Tuc) that seem to exert a structural control on the depth of initial balleno (swale and channel) formation. This is indicated by the dashed line in the X-X' section. Further upstream, at about 3700 feet elevation, such resistant layers, (zeolites help form the resistant internal structure; cf Kelly, 1977), form the exposed channel beds. The differential weathering and porosity of this formation prior to the present erosive episode probably served as a perched groundwater reservoir transporting water to streams downslope from recharge areas, such as the broad Batamote system, and areas above 4200 feet elevation in the Lobo Peak area.

Figure 5 is a map of the Tertiary and Quaternary units and topography above 4000 feet elevation, and hence is a continuation of figures 2 and 3. Of interest is the passage of Proctor Wash through this area dense with structural features.

From the Lobo Peak area a dashed line encloses an area of Holocene floodplain composed of a black organic A horizon 4 to 6 inches thick, overlying increasingly coarse grey alluvium downward. Four to five feet below the surface another buried soil horizon is encountered. The surface canopy is comprised of mature bosque mesquite and Arizona Oak. On hill slopes are scarce old Alligator bark Juniper at 4500 feet elevation. Following the dashed floodplain line southward it enters a funnel-shaped constriction where the stream crosses a lineament that also happens to be a projection of a mapped fault. In this funnel the active channel cuts at an increased gradient. The surface of the oak-mesquite bosque, however, seems to have formed, prior to entrenchment, a retaining deposit across the upstream opening of the funnel.

The steep slopes on the eastern side of the floodplain, particularly along the roughly north-south trending fault that passes by Lobo Peak, and the lineament that also is a projection of a roughly perpendicular running fault along the contact of the Tc unit, have bare scarps where the soil and vegetation cover (mostly perennial grass) has fallen from under the roots of old established trees.

A possible scenario of action for this area of the upper portion of Proctor Wash is that the energy from the Bavispe earthquake was concentrated along older established seismic surfaces, shaking loose the floodplain dam across the constricted hard bedrock outlet, and creating some surface slumping on the steeper fault related scarps.

Possible evidence of upstream erosion and silting deposition at the entry into Sopori Wash is found in the area seen in figure 6. The stipled areas along Proctor Wash below 3300 feet are comprised of dark brown/black soils that grade into the old Sopori floodplain. Black organic lenses of cienega-marsh habitats are turbulently overlain by tan silts derived from the Holocene floodplain deposits eroded upstream. Eventually, this area at the confluence of Proctor Wash bosque with the Sopori marsh would be cut down from 5 to 10 feet as a result of the erosion in the de-watered and degrading system.

A summary diagram of structures across lower Proctor Wash in the area of profiles AA' and BB' on figure 6 is presented in figure 7.

A long-term trend of channel confinement is seen to develop from the Middle Pleistocene to the present. This may be related to a long term drying of climate, as well as processes concerned with the development of the Tucson Basin hydrogeology (e.g. vide Davidson, 1973). The de-watering and degradation of this once perennial bosque-marsh system could be indicated in time by the line of old stumps of trees shown in figure 7 and labelled as event "3.5", where the perched water table dropped faster than the higher trees (bosque mesquites) could extend roots to the phreatic surface. This "3.5" event and the turbulent covering of organic cienega lenses by tan silt could indicate quick processes associated with the 1887 earthquake.

Conclusion

A regional change in riparian environment has been occurring since the 1880's (Cooke and Reeves, 1976), and is impacting the perennial riparian and cienega environments today (Hendrickson and Minckley, 1984). This process of hydraulic change and habitat loss has been documented by Betancourt (1986) for the lower Santa Cruz River at Tucson, and is firmly associated with the confluence of human impacts that de-watered floodplain storage, and fluctuations in rainfall and drought.

The time of human impacts and rainfall-runoff process fluctuations is also imprinted upon long-term broad basin processes and seismic events. The sensitivity shown by the Santa Cruz system to human impacts suggests that hydro-ecosystems can function as geosystem amplifiers that magnify human perturbations.

Figure 8 shows the location of present and lost perennial riparian and cienega locations in the Santa Cruz system. Hydro-environments from Tucson to about 3700 feet elevation have been lost, and hydraulic readjustment is probably affecting existing hydro-environments at about 4000 feet. This suggests that management of the remaining perennial riparian and cienega habitats should be undertaken on a broad regional inter-connected basis; these habitats are prime areas of recharge to the supporting and connecting hydraulic system that feeds back the impacts of land-use policy and management throughout the hydraulic system connections.

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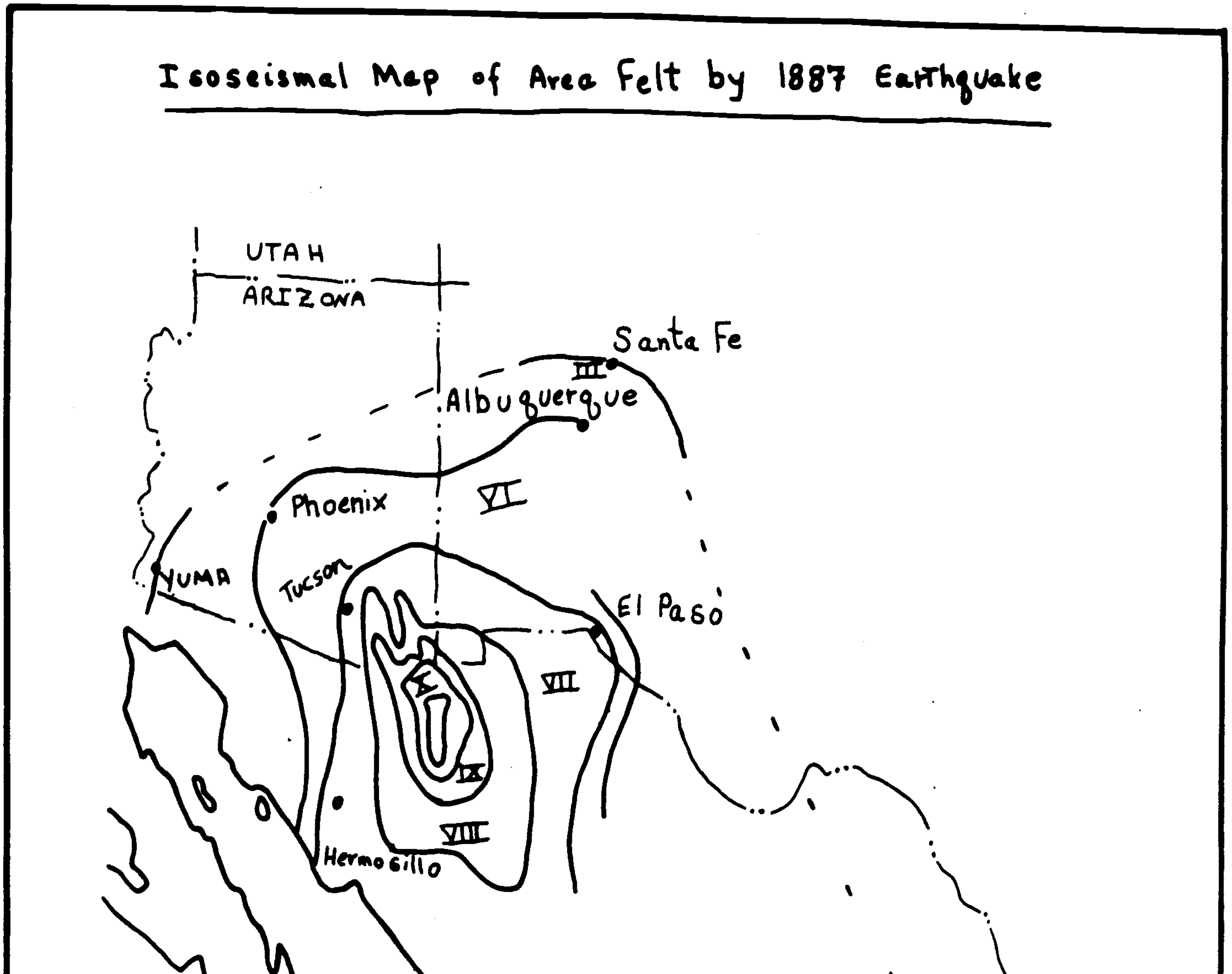
Isoseismal Map of Area Felt by 1887 Earthquake
UTAH
ARIZONA
Santa Fe
III
Albuquerque
VI
Phoenix
YUMA
Tucson
El Paso
X
VII
IX
VIII
Hermosillo
III
XI
Modified Mercalli Intensity values
250 km
Mexico City
After Dubois and Smith 1980

FIGURE 1

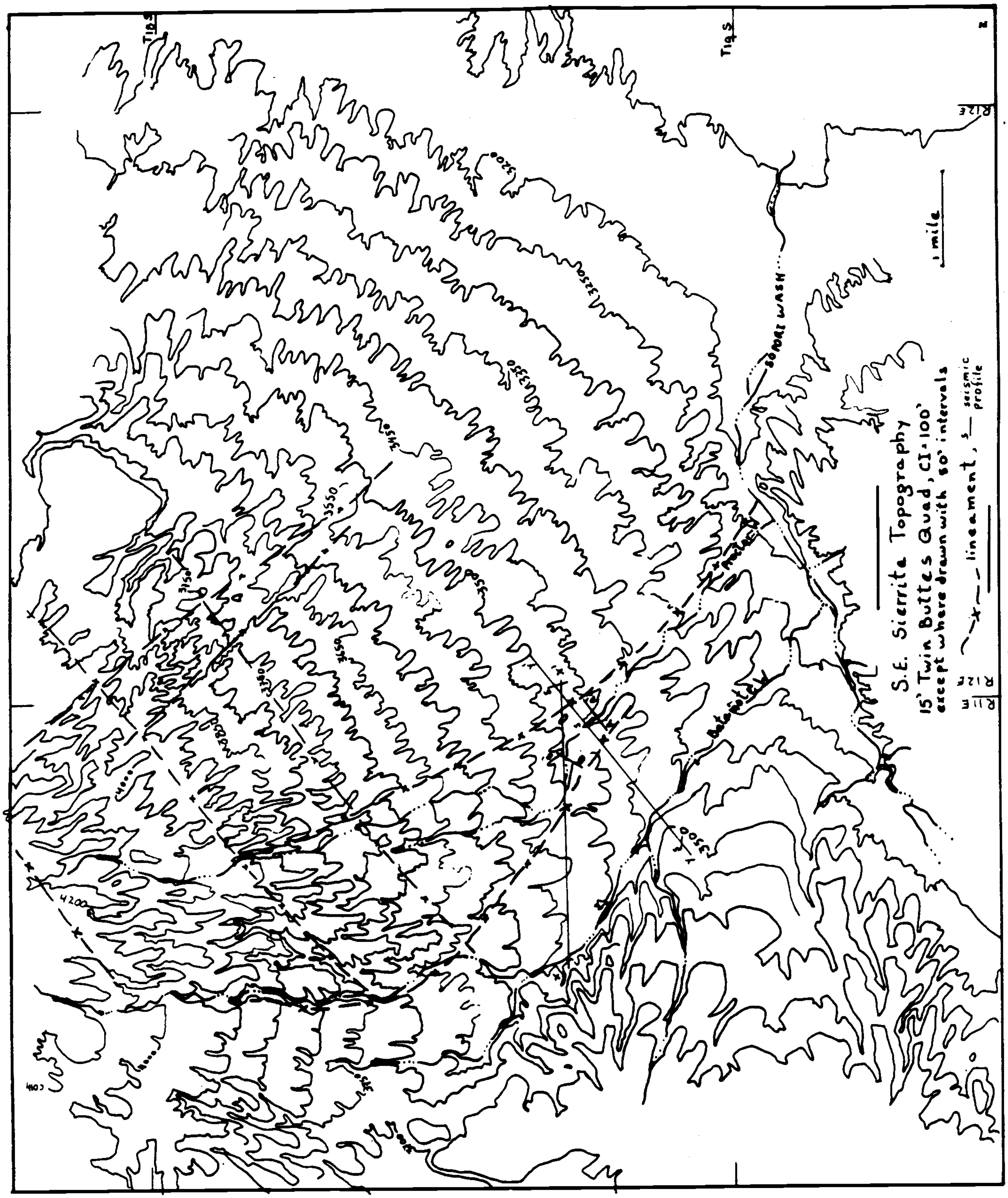
S.E. Sierrita Topography
15' Twin Buttes Quad, CI-100'
except where drawn with 50' intervals
lineament
seismic profile
1 mile
SOPORI WASH
T19S
R12E
R11E

FIGURE 2

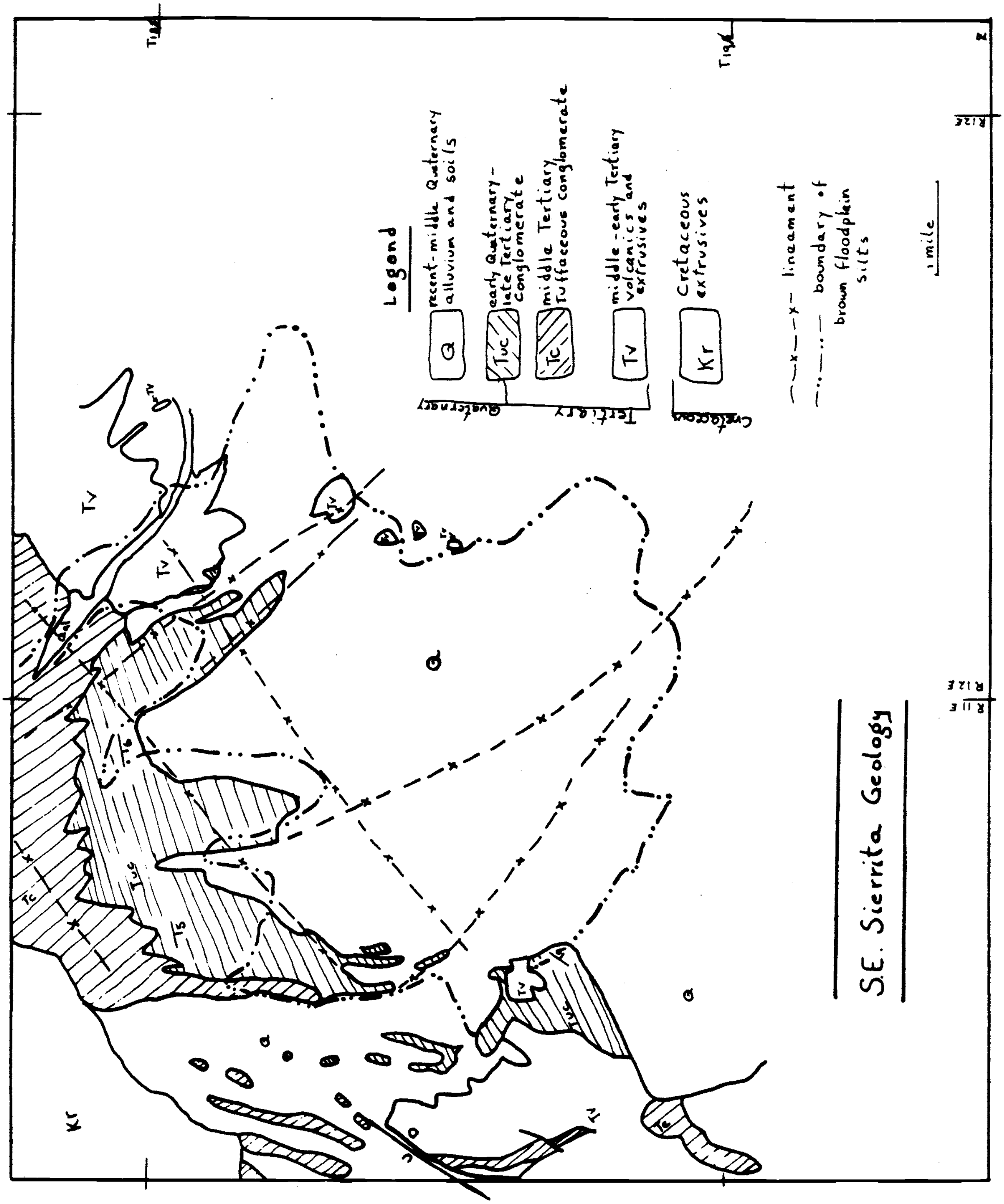
S.E. Sierrita Geology
Legend
Quaternary
Q recent-middle Quaternary alluvium and soils
Tuc early Quaternary - late Tertiary conglomerate
Tertiary
Tc middle Tertiary Tuffaceous conglomerate
Tv middle-early Tertiary volcanics and extrusives
Cretaceous
Kr Cretaceous extrusives
—x—x— linaament
—·—··— boundary of brown floodplain silts
1 mile
R11E
R12E
N

FIGURE 3

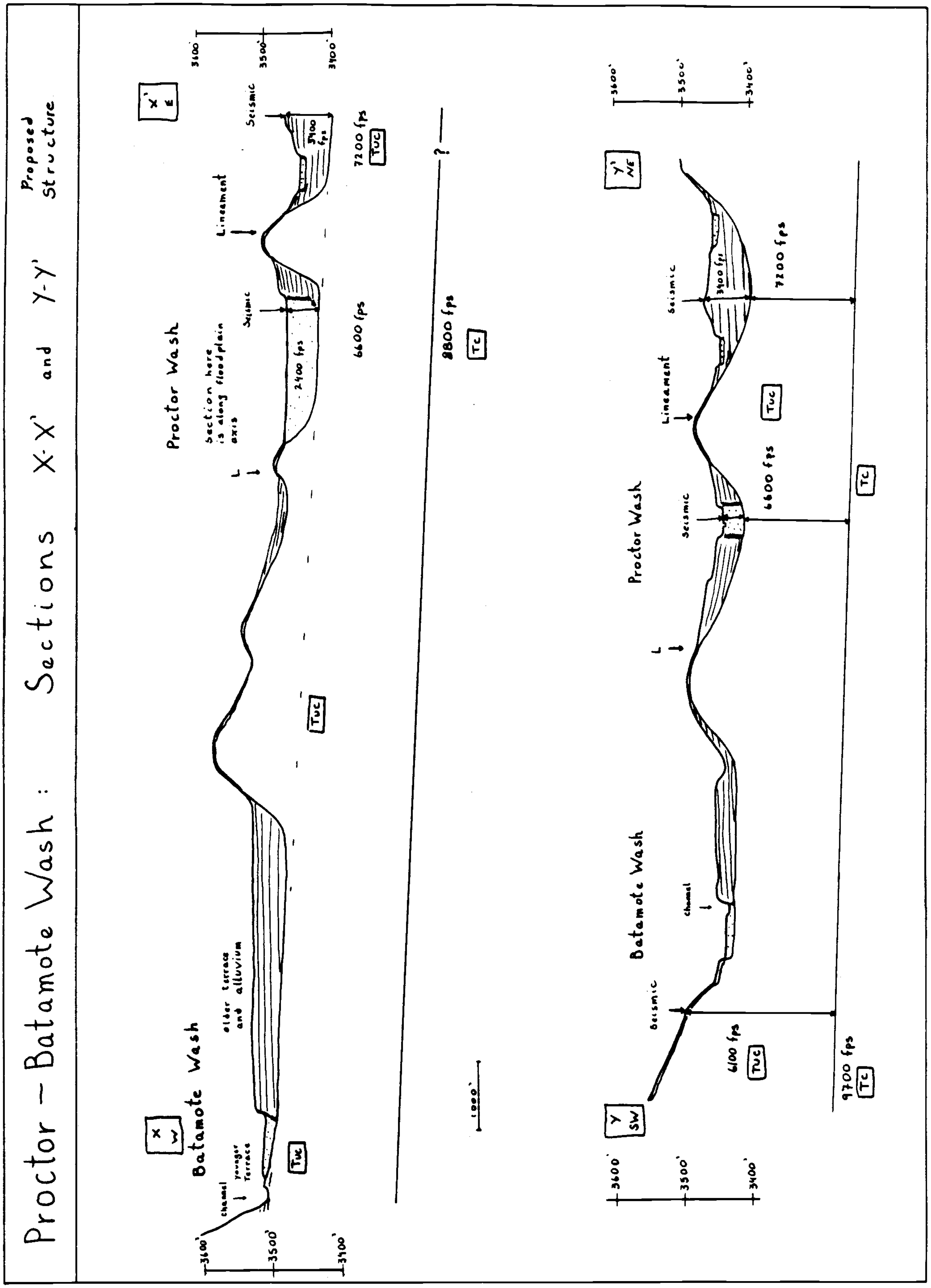
Proctor – Batamote Wash : Sections X-X' and Y-Y'
Proposed Structure
X W
X' E
Batamote Wash
Proctor Wash
channel
younger Terrace
older terrace and alluvium
Section here is along floodplain axis
Lineament
L
Seismic
2400 fps
3900 fps
6600 fps
7200 fps
8800 fps
Tuc
Tc
1000'
3600'
3500'
3400'
Y SW
Y' NE
6100 fps
9700 fps

FIGURE 4

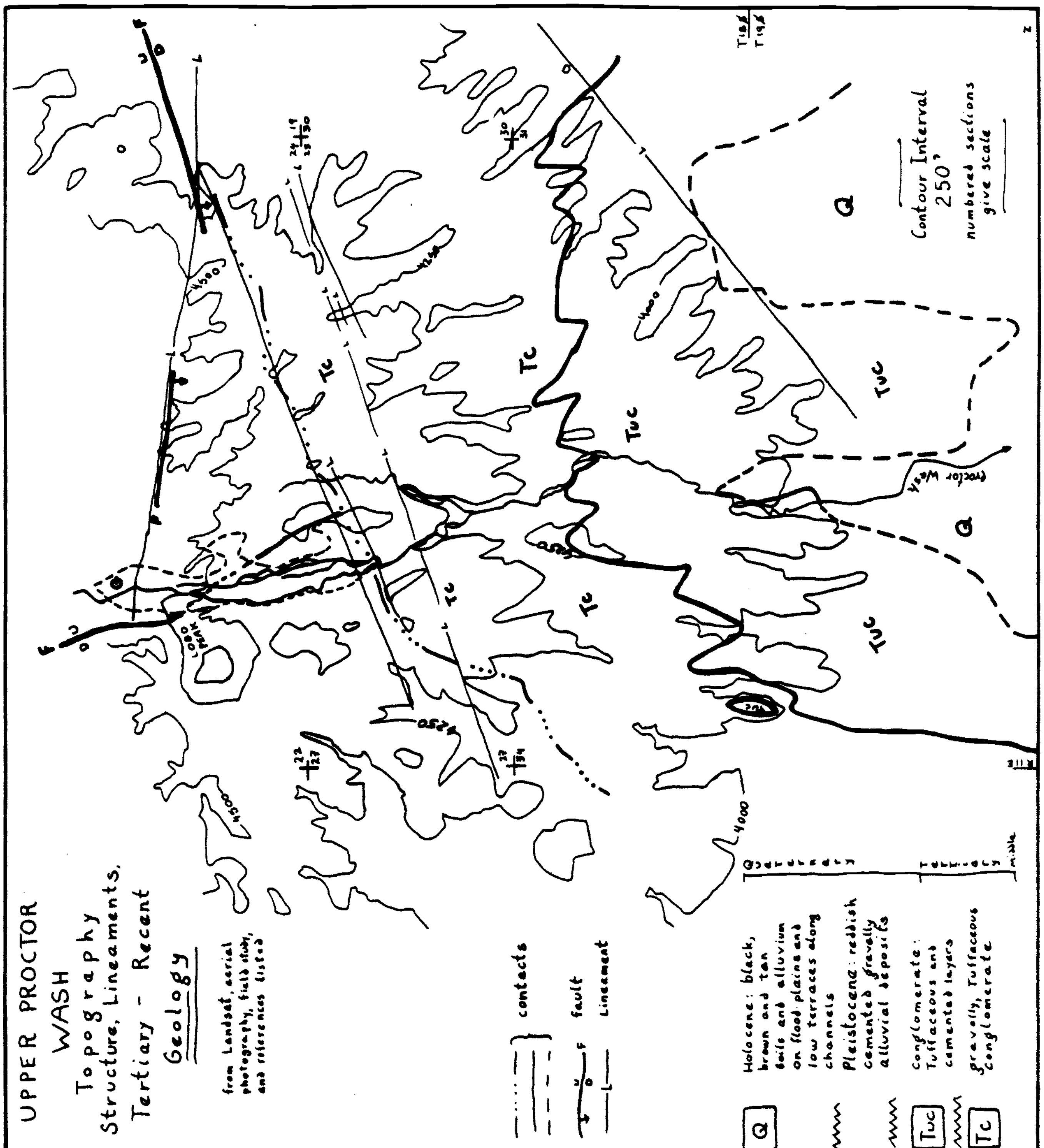
UPPER PROCTOR WASH
Topography
Structure, Lineaments,
Tertiary - Recent
Geology
from Landsat, aerial photography, field study, and references listed
contacts
fault
Lineament
Q
Holocene: black, brown and tan soils and alluvium on flood-plains and low terraces along channels
Pleistocene: reddish cemented gravelly alluvial deposits
Tuc
Conglomerate: Tuffaceous and cemented layers
Tc
gravelly, Tuffaceous Conglomerate
Quaternary
Tertiary
Contour Interval
250'
numbered sections give scale
LOBO PEAK
Proctor Wash
Tc
Tuc
Q
4000
4250
4500

FIGURE 5

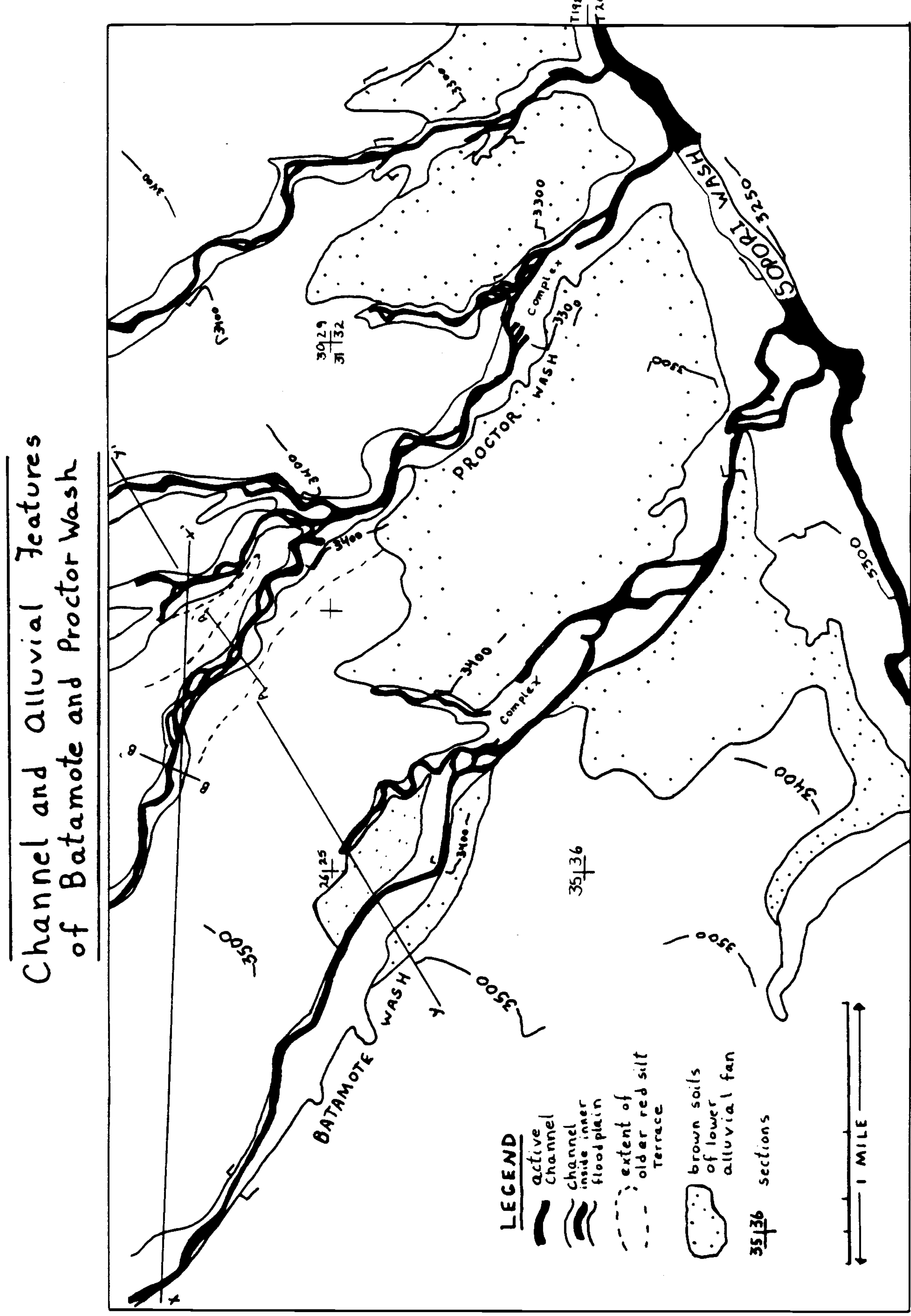
Channel and Alluvial Features
of Batamote and Proctor Wash
LEGEND
active Channel
Channel inside inner floodplain
extent of older red silt Terrace
brown soils of lower alluvial fan
sections
1 MILE
BATAMOTE WASH
PROCTOR WASH
SOPORI WASH
Complex
T19S
T20S
R11E
R12E
3250
3300
3400
3500

FIGURE 6

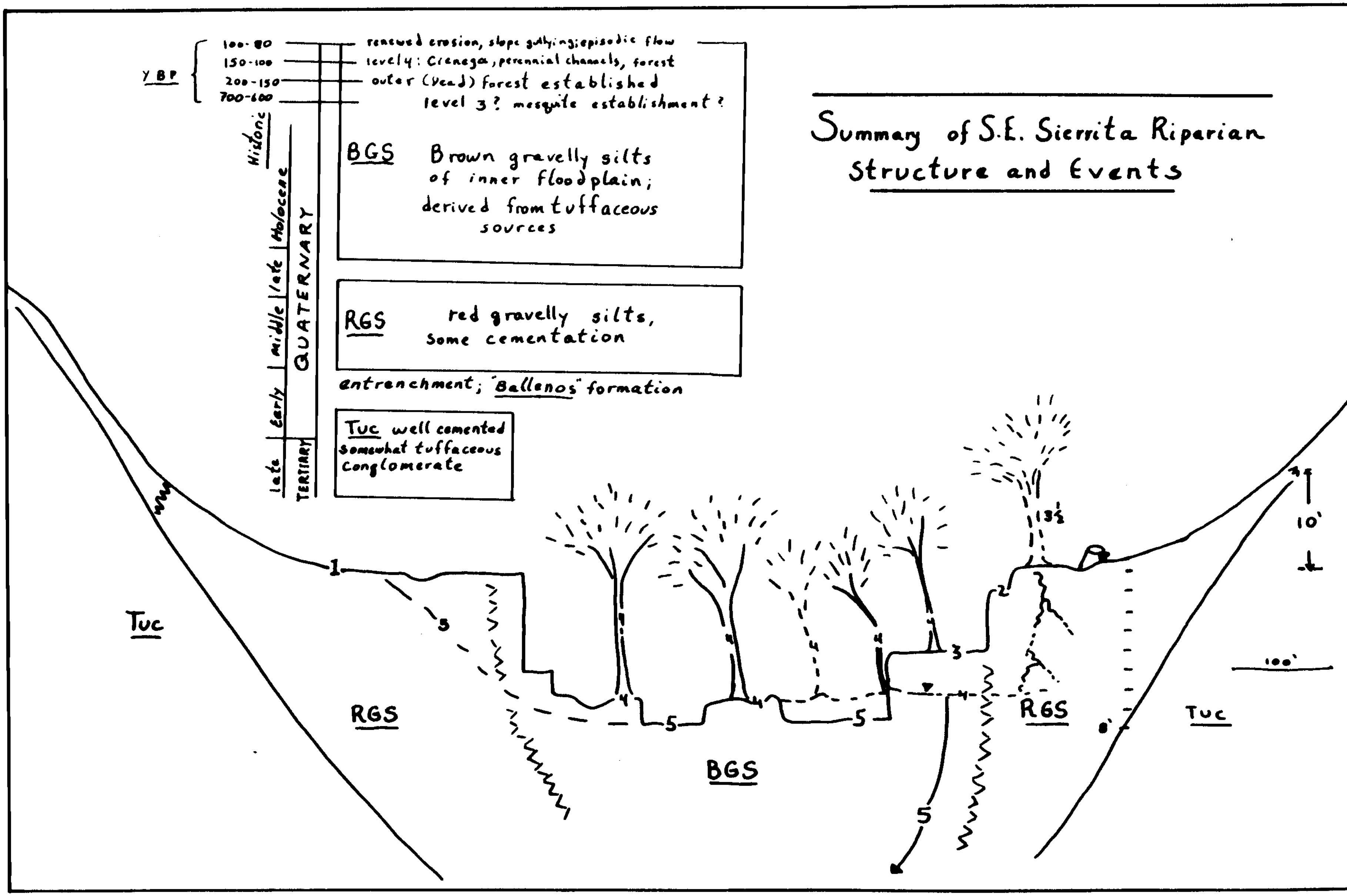
Summary of S.E. Sierrita Riparian Structure and Events
Y BP
100-80
150-100
200-150
700-600
renewed erosion, slope gullying; episodic flow
level 4: Cienega, perennial channels, forest
outer (dead) forest established
level 3? mesquite establishment?
Historic
Holocene
late
middle
Early
late
QUATERNARY
TERTIARY
BGS Brown gravelly silts of inner floodplain; derived from tuffaceous sources
RGS red gravelly silts, some cementation
entrenchment; "Ballenos" formation
Tuc well cemented somewhat tuffaceous conglomerate
Tuc
RGS
BGS
RGS
Tuc
10'
100'

FIGURE 7

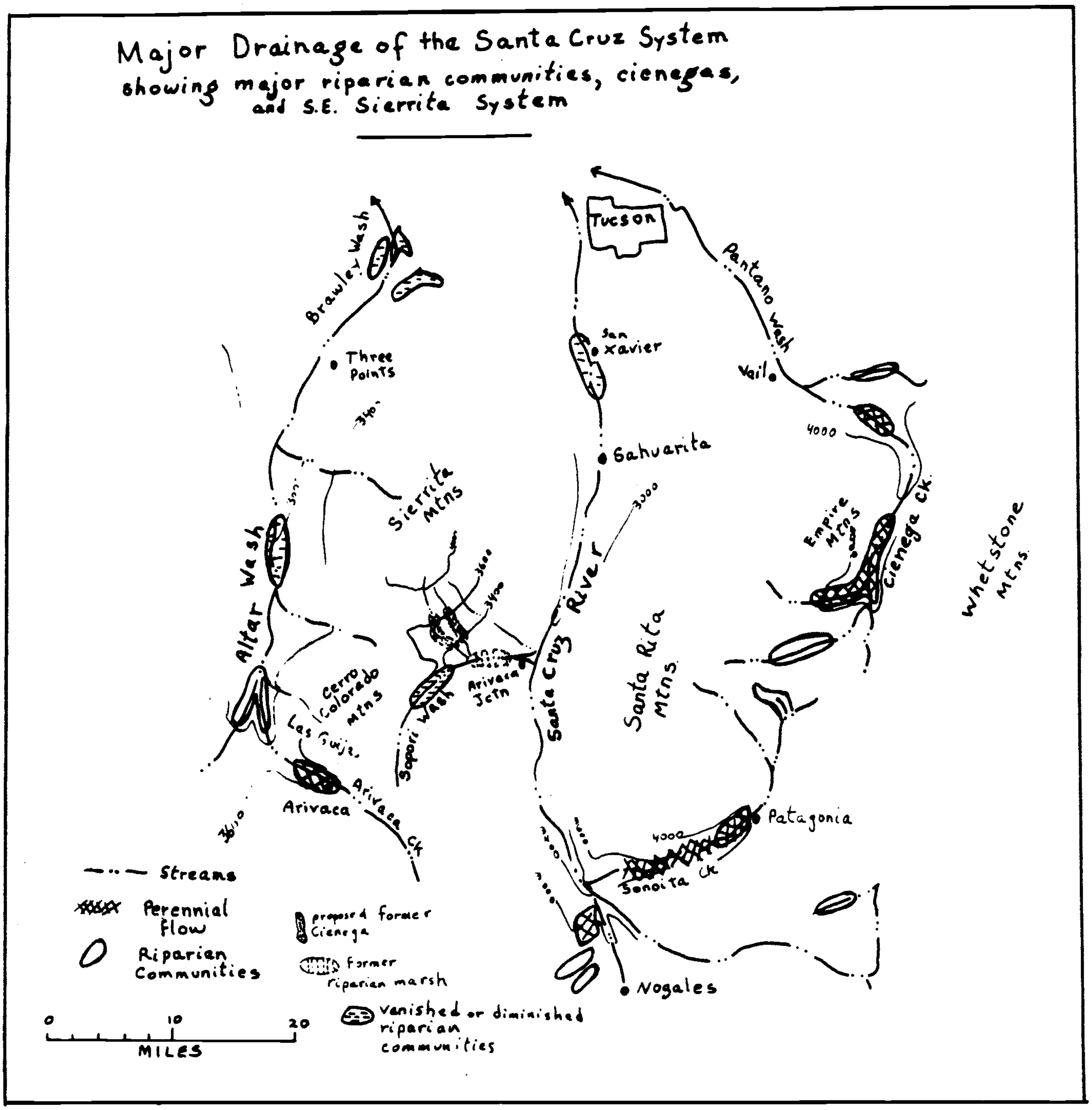
Major Drainage of the Santa Cruz System
showing major riparian communities, cienegas, and S.E. Sierrita System
Tucson
Brawley Wash
Pantano Wash
Three Points
San Xavier
Vail
Sahuarita
Sierrita Mtns
Altar Wash
Empire Mtns
Cienega Ck
Whetstone Mtns
Santa Cruz River
Santa Rita Mtns
Cerro Colorado Mtns
Sopori Wash
Arivaca Jctn
Las Guijas
Arivaca
Arivaca Ck
Patagonia
Sonoita Ck
Nogales
4000
3000
Streams
Perennial Flow
Riparian Communities
proposed former Cienega
Former riparian marsh
vanished or diminished riparian communities
0
10
20
MILES

FIGURE 8