

Late Quaternary Paleohydrology of Arroyo Cycles in the Mixteca Alta, Mexico: Insights from Past and Present Alluvial Stratigraphy

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Arroyos are incised, ephemeral dryland streams that aggrade and incise on a cyclical timescale. Arroyo studies are integral to understanding landscape evolution in drylands, but the drivers and dynamics of arroyo cycles are not fully understood. This paper presents a study of arroyo stratigraphy in the semi-arid environment of the Mixteca Alta, Oaxaca, Mexico. Examination of the late Quaternary environment and geomorphology of the incised, ephemeral tributaries forming the Río Culebra watershed offered insight about the hydrological variability of the region. The characteristics and chronology of alluvium-paleosol sequences from three watersheds in the Mixteca Alta were examined along their upper, middle and downstream sections. In addition, the channel bedforms and stratigraphy of several watersheds were surveyed to evaluate the processes and morphology characterizing the present dryland stream system.

Alluvium-paleosol sequences offered valuable information into the paleohydrology and dynamics of the arroyo cycles of the Mixteca Alta. Unweathered alluvium and paleosol formation in alluvium are two end members of alluvial stratigraphy. Cumulic A horizons form on floodplains when aggradation is slow enough to allow for pedogenesis. Cumulic A horizons were observed in both the Culebra and Verde watersheds from the late Pleistocene to the late Holocene, but not in the present-day arroyos, suggesting the prehistoric cumulic A horizons form in less flashy conditions than modern conditions.

The geomorphic survey of present-day processes and forms included observing the bed stratigraphy associated with scouring-chains after flash floods. This examination offered insight to understanding and interpreting the alluvium-paleosol stratigraphy. For example, the present channel bed stratigraphy associated with scour-and-fill consists of poorly sorted, massive, sandy gravel deposits. Finer bedded sediments are observed in the present patchy floodplain deposits, but are susceptible to erosion. In contrast, the Quaternary stratigraphy is dominated by extensive fine sediment deposits, having thin bedding and laminations, while coarser, massive strata are observed, but to a lesser extent. The less prevalent coarser strata are analogous to present-day flash floods deposits, whereas the more widespread finer strata indicates a different flood regime associated with arroyo fills.

Comparing the alluvium-paleosol chronology of the Mixteca Alta watersheds against high-resolution records from regional paleoclimatic proxies, such as stalagmites, offered insight concerning the climatic regime associated with different alluvial sequences. For example, incision was typically associated with wet periods, while alluvial strata were deposited during relatively drier periods. In addition, land use activities interacted with climate to produce hydrologic changes at a local scale prior to the Post-Classic period (e.g., local Natividad phase (1,250-430 cal BP). Afterwards, widespread land use interacted with climate to affect hydrological changes on the watershed scale. The present system of Río Culebra appears to be in complex response, adjusting to the long-term and short-term influences of late Holocene climate variation, legacies of prehistoric land-use change, and modern land use activities.