Terrace Stratigraphy and Soil Chronosequence of Cañada Alamosa, Sierra and Socorro Counties, New Mexico

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ABSTRACT

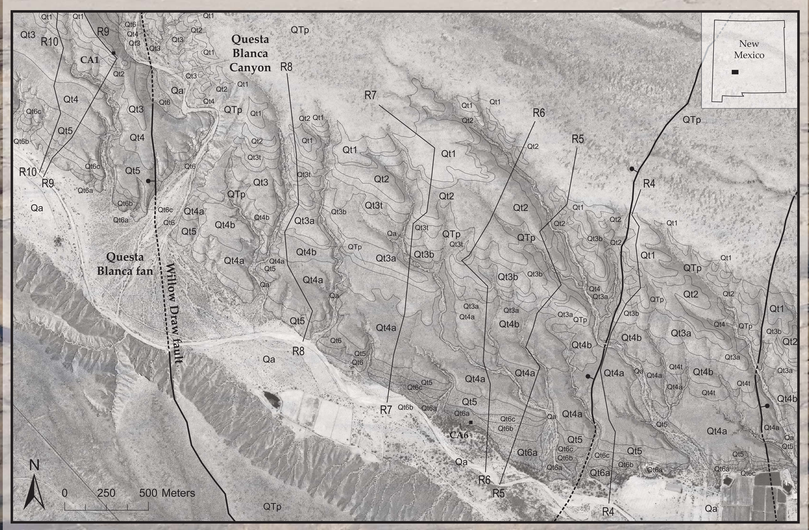
A total of six major terraces of probable climatic origin incised into the Palomas Formation of the Santa Fe Group make up the terrace stratigraphic framework for Cañada Alamosa, a large tributary of the Rio Grande, whose mouth lies some 25 km upstream of Truth or Consequences, New Mexico. The tread heights of these terraces extend from 9-16 m to 76-83 m above the modern floodplain and thicknesses range from 4.7 m to 18 m or more. Quaternary tectonism along the Cuchillo Negro fault zone has offset or warped the oldest four terraces and created two localized terraces, suggesting relative age of movement along faults from ~0.55 to ~0.32 Ma. Minor structural perturbations and/or complex response of transport/depositional systems are responsible for additional local terrace surfaces along the lower four terrace levels. A total of 11 terraces were mapped.

The effects of intercanyon and intraterrace spatial soil variations somewhat diminished the effectiveness of the soil chronosequence developed from profiles examined on five of the six terraces in this study. Soil profile CA3 on terrace Qt3 shows the maximum amount of development, more so than the profile CA1 on the oldest, highest terrace Qt1. Nevertheless, soils generally exhibit increases in pedogenic fines (silt + clay percentages increasing from 7.5 to 26.4 %) and carbonate development (stages I to III) with age. Soil Development Indices reflect this as well and correlate ($r^2 = 0.776$) with values derived from the Desert Project soils with known ages, indicating that Cañada Alamosa terraces fall within the established southern New Mexico alluvial morphostratigraphy.

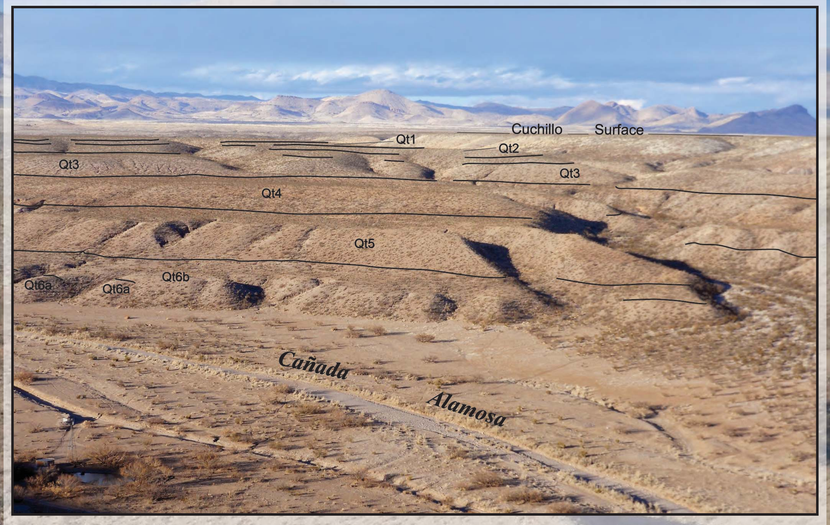
A relative age chronology is suggested, with ages based upon the rate of incision, degree of pedogenesis, and the timing of glacial cycles recorded in the marine oxygen isotope record of the equatorial Pacific. Following cessation of Palomas Formation aggradation at ~0.8 Ma, the Rio Grande has downcut some 90-100 m into the abandoned Cuchillo geomorphic surface in a series of climatically-driven episodes of incision punctuated by periods of partial backfilling. Cañada Alamosa terraces Qt1-Qt6 likely formed following tread abandonment at ~0.67-0.63, ~0.58-0.56, ~0.45-0.43, ~0.38-0.32, ~0.15-0.12 Ma, and ~17-15 ka, respectively.

OVERVIEW

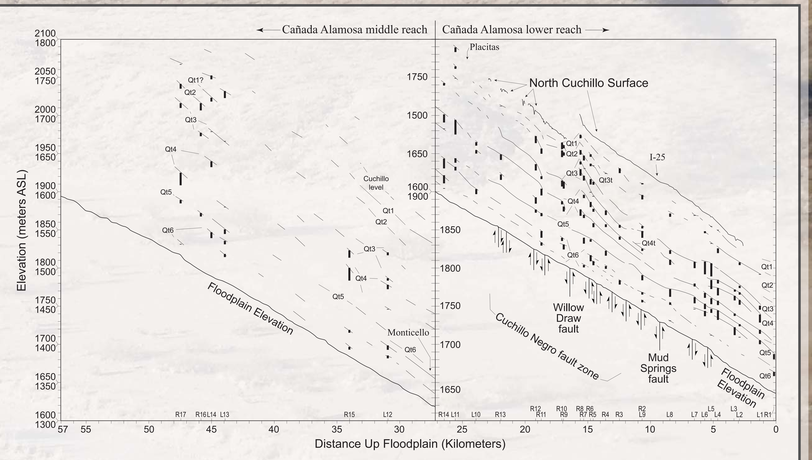
In McCraw and Williams (2012), the terrace stratigraphy of Cañada Alamosa was examined based upon 31 topographic profiles, large-scale (1:6,000) mapping of two study areas within the canyon, and a soil chronosequence developed from the characterization of six soil profiles excavated to a depth where parent material could be recognized. Based upon these investigations, the neotectonic alteration and adjustment of the resulting terrace stratigraphy, comprised of six major climatic terraces, were comstrained within the southern New Mexico morphostratigraphy and a relative age chronology was produced.



Map of Cañada Alamosa terraces (Qt map units) developed in the Palomas Formation (map unit QTp), showing three faults of the Cuchillo Negro fault zone cutting the Cuchillo surface and the inset terraces. Location of soil profiles CA1 and CA6, as well as topographic profiles R4-R10 are shown. Younger terraces Qt3-Qt6 exhibit multiple terrace surface levels, either due to complex response or neotectonism, as is the case for tectonic terraces Qt3t and Qt4t.



North-northeast-looking view of the six major terraces of Cañada Alamosa, located about 0.5 km west of Questa Blanca Canyon (reference location map to the left) in the lower reach.



Location and distribution of Cañada Alamosa terrace treads above the floodplain for the lower and middle reaches. The profiles of the northern Cuchillo surface and the floodplain were derived from 2009 1-meter NAIP (National Agriculture Imagery Program) DEM (Digital Elevation Model) terrain data. The vertical boxes show ranges of tread heights measured from 31 DEM-based topographic profiles on both north canyon (right) and south canyon (left) walls. Estimated extents of treads are indicated by lines running roughly parallel to the floodplain. Tectonic-induced tread offsets and warping are evident in the older terrace treads Qt1-Qt4.

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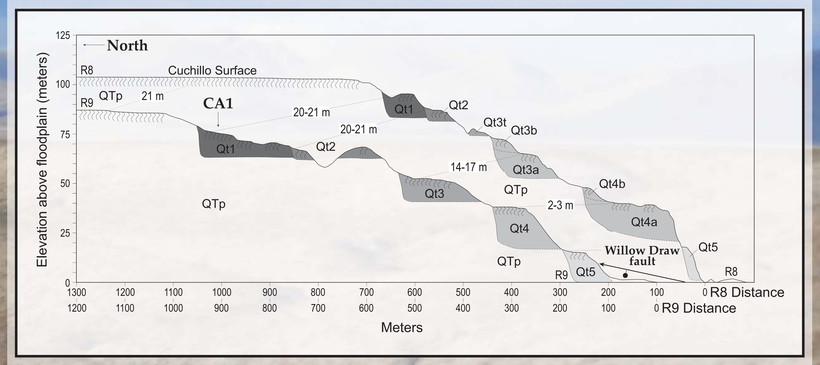
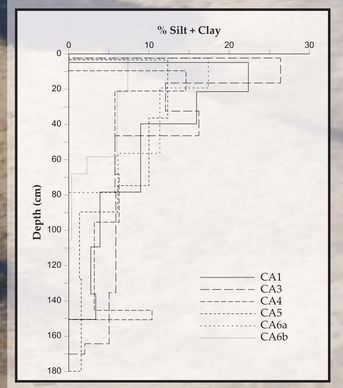
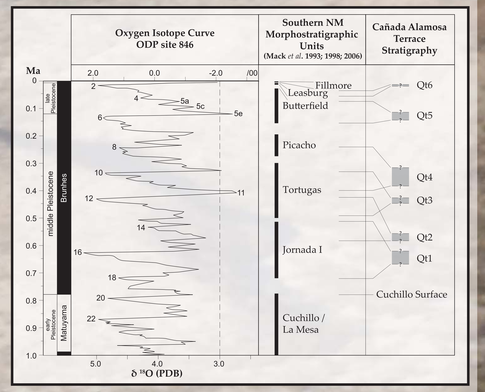


Topographic profiles R8 and R9, illustrating the amount of terrace tread offset on either side of the Willow Draw fault. Profile R8 shows the tectonic terrace Qt3t, which resulted from rupture(s) between Qt2 and Qt3 time. Profile R9 passes through soil profile CA1 locality.





LEFT - The figure on the left shows the percentage of the silt + clay grain size fraction with depth for soil profiles CA1 and CA3-6a-b.

RIGHT - The figure on the right shows the relative ages suggested for the Cañada Alamosa terrace stratigraphy constrained within the southern New Mexico morphostratigraphy (from Mack et al., 2006, fig. 13, p. 159) and calibrated against the marine oxygen isotope curve for the equatorial Pacific ODP (Ocean Drilling Program) site 846 (Cande and Kent, 1995). Numbers adjacent to the isotope curve refer to marine isotope stages, odd numbers correspond to interglacials, even numbers to glacial periods.

CONCLUSIONS

The terrace stratigraphy of Cañada Alamosa is comprised of six major terraces, which are incised into the Plio-Pleistocene Palomas Formation. The parallel form of their treads and the correlation of their tread heights with terraces flanking other Rio Grande tributaries in the region are indicative of a primary climatic origin. The effects of Quaternary climatic cycles are recorded in the terraces, by varying degree of pedogenesis. Upon this climatic terrace framework, the effects of neotectonics and complex responses have locally altered and complicated the stratigraphy. The four oldest terraces are warped and offset, reflecting tectonic movement since sometime between ~0.55 and 0.44 Ma, presumably closer to the latter. Two minor terraces of probable tectonic formation (Qt3t and Qt4t), most likely the result of ruptures occuring slightly before Qt3 and during Qt4 times, are locally preserved. Additionally, climatic terraces Qt3-6 are locally imprinted upon with minor terraces (surface levels) formed from complex response, recording minor pauses in degradation as the stream adjusted to downstream perturbations, most likely tectonic in nature.

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