UNRAVELLING FAN-CLIMATE RELATIONSHIPS: MILANKOVITCH CYCLICITY IN A MIOCENE ALLUVIAL FAN (TERUEL BASIN,SPAIN)

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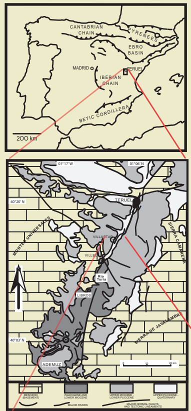
Relating allogenic forcing to the architecture of coarse-clastic successions at basin margins proves difficult, since high-resolution chronology and proxy-series are hard to obtain from such deposits. We present an approach by detailed correlation of the orbitally tuned Prado section (Late Miocene, mudflat to eph emeral lacustrine facies) to distal gravel lobes of an adjacent, coeval alluvial fan. Interfingering relationships between the two depositional systems allow paleoclimatic and chronological information, derived from the recognition of Milankovitch cycles in the reference section, to be applied in interpreting the fan's sedimentary dynamics on millennial timescales.



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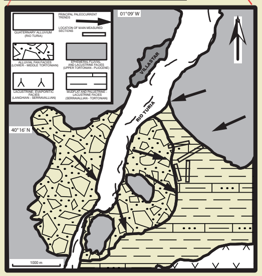
1. BACKGROUND AND SETTING

Relationships between alluvial fan dynamics and allogenic controls are a subject of debate in the literature. Such geomorphic systems are not only highly sensitive to several forcing factors interacting over superposed timescales, given their relatively small size, but are also subject to autocyclic processes.
Tectonics have been the classic key to interpret fan sequences in the rock record, whereas climate stands out mainly in studies of Quaternary successions, for which both high-resolution dating and paleoclimate proxies are more readily available. In continental settings with high preservation potential and sensitivity to climate variability, referring to cyclostratigraphy to gain both chronological and paleoenvironmental information can be an approach in the analysis of coarse-clastic successions.

The Teruel Basin (eastern Spain; **1**) is an association of half-grabens developed from late Oligocene to Pliocene under semi-arid climate conditions. In the central sub-basin, near Villastar (**2**, **3**), fine-grained clastics and (bio)chemical carbonate facies from mudflat and ephemeral lacustrine systems (**Prado Section**) intercalate with coarse-clastic alluvial fan deposits sourced by the adjacent tectonic margin.



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2. PRADO SECTION: ASTRONOMICAL CLIMATE FORCING OF FACIES CYCLES

Integrated bio-, magneto- and cyclostratigraphy of the Prado Section allowed to tune stacking patterns of basinal facies to astronomically forced insolation curves (**4**). A clear orbital precession signal, expressed as basic, m-scale facies rhythms, is superimposed on longer-term modulation of facies associations related to orbital eccentricity cycles.

In the basal part of the section, basic facies rhythms (**3**) consist of alternating, massive, reddish claystones and light-brown sandy siltstones, with respectively, relatively low and high amounts of mottling, rhizoturbation and carbonate content, and associated incipient calcrete horizons.

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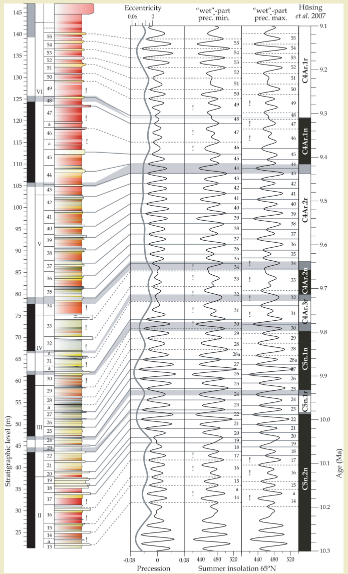

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Facies cycles are interpreted in terms of alternating, precession-driven, relatively humid-arid phases.
Precession minima (insolation maxima) would witness a positive hydrological balance due to elevated Mediterranean surface temperatures and consequently enhanced winter precipitation (Ca-rich, sandy siltstones and incipient calcretes).
Precession maxima (insolation minima) would result in a negative hydrological due to relaitvely reduced precipitation in the face of constantly high rates of summer evaporation (claystones).

3. ALLUVIAL FAN CYCLICITY

Distal, coarse-clastic lobes from a coeval alluvial fan (**2**) interfinger with the Prado Section, at stratigraphic positions regularly correlative to calcrete horizons in mudflat facies. Exact stratigraphic and chronological correlation with m-scale facies rhythms of the Prado Section is confirmed by traceability of several coarse-clastic units into distal pinch-outs, where they are expressed by thin beds of pebbly sandstones (**5**, **6**).

Attribution of climatic significance to the facies in the Prado Section allows therefore to relate times of highest volume of clastic transport basinwards to relatively humid phases within the semiarid context of the Teruel Basin.

Confirming the view from the most distal fan deposits, outcrops in the medial segment of the paleofan body present an unusually ordered stratigraphic architecture featuring a repetitive stacking of alternating coarse- and fine-clastic packages (**7**).

The possibility that local tectonics or autogenic processes, rather than climate, would have regulated stratigraphic development of the Villastar Fan can be discounted since such processes would not have generated facies patterns matching the insolation curve.

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4. IMPLICATIONS FOR ALLUVIAL FAN RESEARCH

- Stratigraphic evidence from the Prado area demonstrates the possibility that long-term evolution of alluvial fan systems may be driven by climate forcing. Variable climate parameters through time can influence sedimentation patterns via mediating effects of varying catchment hydrology, weathering and vegetation.
- Facies relationships between the orbitally tuned Prado Section and the Villastar Fan show that the latter was sedimentologically more active at times of relatively humid climate, countering the common idea, based on shorter-term Quaternary-based studies, that fan construction would be effective mainly during arid phases.
- Application of cyclostratigraphy to the analysis of alluvial fan successions can significantly enhance our understanding of sedimentation and stratigraphic architecture in such systems, both in terms of chronological resolution (down to ~10 Ky and less) and basinal controls.

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