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The neogene-quaternary basins of the betic cordillera: an overview

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The Neogene Betic Basins. Geological Context.

During the Neogene, sedimentation in the Betic Cordillera took place in two geodynamically different phases. During the first of these (Early and Middle Miocene) the Betic basins evolved simultaneously with the main movements of orogenic structuring of the Cordillera, which were the collision between the Alboran Microplate (that would later make up the Internal Zones) and the South-Iberian Palaeomargin (whose deformed rocks made up the External Zones), together with the extensional detachments of the former and overthrusts in the latter of these domains (Vera, 2001). In this first, markedly synorogenic phase, a number of basins formed within the orogene (to the South), known as Intrachain Basins, as well as a foreland basin outside it (to the North), known as the North-Betic Strait, Proto-Guadalquivir Basin and North-Betic Foreland Basin (Sanz de Galdeano and Vera, 1992; Soria, 1993; Viseras et al., 2004). The sediments filling them, particularly the intrachain basins, are intensely deformed by Betic orogeny, which prevents detailed understanding of their original palaeogeographic boundaries. The second geodynamic phase in which Neogene sedimentation occurred coincided with the Neotectonic Stage (Late Miocene to Quaternary). The main features of the orogene had already been determined and tectonic activity centred on the convergence of Africa and Iberia. This was the context in which the Postorogenic Basins formed, which are located on both Internal and External Zones and on the contact between the two.

Origin of the Postorogenic Basins

In order to outline the complete evolution of the Postorogenic Basins, we must describe the events concluding the previous synorogenic phase. Both the Interchain Basins and the North-Betic Foreland Basin were divided up by the joint action of tectonic and eustatic processes. From a tectonic point of view, the Middle Miocene - Late Miocene boundary is characterised by a regional, post-Serravallian or end of Serravallian - earliest Tortonian event (Soria, 1993) apparent in both the Internal and External Zones. In the former, shear movements occurred, possibly related to extensional detachments, causing emersion and regression. In the External Zones, Subbetic and Prebetic units overlapped northwards on the last Serravallian-earliest Tortonian deposits accumulated in the North-Betic Foreland Basin. As a result of this event the central and eastern sectors of the Betic Cordillera emerged and were subjected to erosion, leaving the North-Betic Foreland Basin limited to just the western sector of the cordillera, where the Guadalquivir Foreland Basin was located.

The geodynamic context during the neotectonic stage of the Betic Cordillera is characterised by N-S to NW-SE regional compression, responsible for the creation of a complex network of faults striking NW-SE and NE-SW to NNE-SSW (Sanz de Galdeano and Vera, 1992), which acted jointly with others striking N70ºE and E-W inherited from the orogenic phase. In relation with this fault network, the Postorogenic Basins formed in the reliefs raised towards the end of the orogenic phase.These are polygonal basins subjected to considerable subsidence, partially interconnected and separated by uplifted sectors. Eustatism is shown by a sea-level rise in the Tortonian (beginning of.2 the TB3.2 third-order cycle, Viseras et al., 2004) causing regional transgression and the start of marine sedimentation in the subsident basins controlled by tectonics.

Stratigraphic architecture. Main events and depositional environments.

The filling of the Postorogenic Basins can be divided into six allostratigraphic units bounded by major unconformities recognised throughout the Betic Cordillera, whose limits represent tectonic and/or eustatic events (Fernández, et al., 1996; Viseras et al., 2004). The first three units (I, II and III) are Tortonian, the fourth (Unit IV) is latest Tortonian and Messinian or Late Turolian, the fifth (Unit V) is Early Pliocene and the Sixth (Unit VI) Late Pliocene and Pleistocene. There follows a synthetic description of the stratigraphic architecture of these six allostratigraphic units, the tectonic-sedimentary significance of the boundaries between them and the main sedimentary environments occupying the basins.

Unit I (Tortonian). This was the first unit deposited as a result of the transgression beginning marine sedimentation in the Postorogenic Basins. In a rising sea-level context, sedimentation created deepening megasequences and stacking patterns of retrogradant strata. In the basins of the central sector, these megasequences began with coastal deposits evolving towards platform deposits and ending with talus and pelagic basin sediments (Fernández et al., 1996). In more easterly basins, the megasequence began with deltaic deposits, evolving to turbidite talus sediments and ending with pelagic basin materials. All these depositional systems were distributed spatially, making up a transgressive systems tract in each basin.

Unit II (Tortonian). Units I and II are separated by intra-Tortonian event 1 (IT-1) - a phase of deformation in a compressive regime that caused the last overlaps in the External Zones and considerable deformation (folds and progressive unconformities) of the underlying unit. In the basins with marine sedimentation, this Unit is represented by shallowing megasequences with progradant strata, characteristic of a high sea-level situation. In most of the basins these megasequences include, from bottom to top, pelagic basin, talus and platform deposits or deltas with coral reefs. The grouping of these depositional systems define Unit II as a highstand systems tract.

Unit III (Tortonian). The lower boundary coincides with intra-Tortonian event 2 (IT-2), also known as the end of Tortonian event (Soria, 1993; Fernández et al., 1996), which represents a deformation phase responsible for the uplift of much of the central and eastern sectors of the cordillera. The main effect of this event was a rapid fall in sea-level, with a forced regression caused by tectonics, and the formation of shallow marine sedimentary bodies or lowstand systems tracts on deep pelagic sediments of the preceding unit. These shallow sediments are very varied in lithology and sedimentary environment - Gilbert-type deltas, terrigenous platforms and reefs, coastal stromatolites, carbonate platform algal limestones and evaporites.

Unit IV (latest Tortonian - Messinian). The lower boundary of this unit is marked by the final Tortonian event (FT), causing the continentalisation of several basins. Where this unit presents completely continental features, for example, in the Granada and Guadix-Baza basins, a ring of alluvial fans developed on the margins, connected distally with fluvial and lacustrine systems (Viseras et al., 2004), the latter having both detrital and carbonate and evaporitic sedimentation. In cases with marine sedimentation, such as the Bajo Segura Basin, the alluvial ring on the margins evolved towards deltas, and these in turn to coral reef shelves and pelagic basins (Soria et al., 2001). All these depositional systems have progradant geometries, with regressive or shallowing megasequences characteristic of a highstand systems tract. In these basins with marine connection, invariably in central positions of the basin, the upper part of the unit is overlaid by a set of evaporites associated with a marginal ring of stromatolites and terrigenous coastal sediments. These.3 evaporites, representing the first phase of the Messinian salinity crisis, are interpreted as the result of marine reflooding (Messinian transgression) after an initial fall in Mediterranean sea-level. At the top of Unit IV, as recently described in the Fortuna and Bajo Segura Basins, an erosion surface can be recognised with entrenched palaeovalleys filled with conglomerates and sands, that can be interpreted as the second phase of the Messinian salinity crisis, resulting fom a second Mediterranean sea-level fall.

Unit V (Pliocene). In the inner and continental basins of the central sector, this unit is separated from IV by the Miocene-Pliocene boundary event (M-P), representing the end of the predominant compression throughout the latest Miocene. In the inner and marginal basins of the eastern sector, with previous marine sedimentation, the lower limit corresponds to the Pliocene transgressive event or post-Messinian salinity crisis event. In the continental basins of the central sector, a main axial drainage system has been recognised corresponding to a sinuous, coarse-grained fluvial channel and two drainage systems transverse to it, supplied from the reliefs of the Internal and External Zones and consisting of alluvial and deltaic fans. In the more subsident sectors of the basins, located along the axial valleys, lakes developed temporarily, in some cases ephemerally, where carbonate and evaporitic sedimentation took place. After the marine flooding at the beginning of the Pliocene, the erosive palaeovalleys of the second phase of the Messinian salinity crisis in the marine basins of the eastern sector were filled with pelagic sediments, evolving upwards to shelf and coastal deposits, and the latter to alluvial continental materials $s.l.$They thus make up a regressive megasequence with progradant geometry interpreted as a highstand systems tract.

Unit VI (Late Pliocene - Pleistocene). This unit is distinguished from V by the intra-Pliocene event (IP), a change in tectonic regime shown by either a decrease in subsidence rate in the inner basins of the central sector, or by the formation of new structures in a compressive regime in the basins of the eastern sector. In the continental basins of the central sector the sedimentary process remains similar to that of the preceding unit, although there is an increase in the radius of the alluvial fans of the Internal Zones, which merge to form a bajada or braided plain. In the basins of the eastern sector the creation of new tectonic structures, such as the Bajo Segura fault, gave rise to the segmenting of the former basin by forming heights and troughs, the latter occupied by fluvial valleys physiographically similar to the present ones.

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