

Tertiary basins of Spain the stratigraphic record of crustal kinematics

Edited by

PETER F. FRIEND AND CRISTINO J. DABRIO

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the stratigraphic record of crustal kinematics

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W9 Tertiary of Central System basins

A. MARTÍN-SERRANO, J.I. SANTISTEBAN AND R. MEDIAVILLA

Abstract

The rise of the Central System due to reactivation of Late Hercynian fault systems during the Alpine Orogeny directly affected the structure and stratigraphic framework of the basins nearby that were being filled at the same time. The sedimentary record is the essential key to understanding the tectonic and palaeo-morphological history of the Central Range, and vice-versa. Relating the filling of the basins with the definition of the mountain range, pre-arkosic, arkosic and post-arkosic stages have been proposed. However, it is difficult to support the previous idea that the arkosic stage continued throughout the Late Tertiary to finish in Middle Pliocene times with the deposition of the 'Páramos (limestone)'. The arkosics of the Central System are of Eocene-Oligocene age and the highest alluvial-fan deposits may be of Aragonian age. There is only a poor record of the remaining Tertiary and Quaternary sediments, because of active river incision during this time in the basins, the ranges and elsewhere in the Spanish Meseta.

Introduction

The Central System is a complex inverse horst-graben system that developed during the Tertiary. The Plasencia fault separates two morphostructural domains: a western domain with large mountain blocks and basins oblique to the range, and an eastern one with large highs and minor basins parallel to the general structure (Fig. 1).

Western basins

The western domain is bounded by two main fault families: ENE-WSW to NE-SW and NW-SE to WNW-ESE (Moreno, 1990). The most important sediment accumulations are preserved in its lowest areas: Ciudad Rodrigo, Moraleja (Castelo Branco), Coria and Zarza de Granadilla.

The Ciudad Rodrigo Basin is a half-graben bounded to the south by a complex NE-SW-trending fault. Its infill is controlled by:

- (a) asymmetry, with thicknesses up to 600 m S of Ciudad Rodrigo (Fernandez Amigot, 1981);

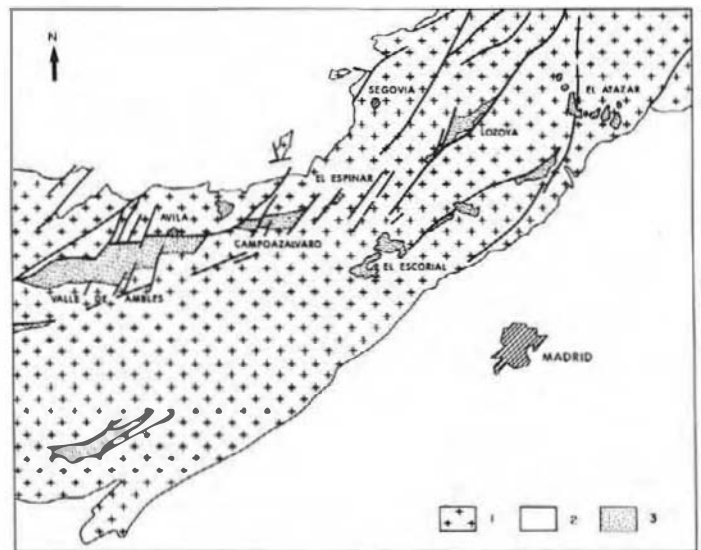


Fig. 1. Tertiary outcrops in western Central System. 1, Pre-Tertiary substratum; 2, Tertiary deposits of Duero and Tajo basins; 3, Tertiary deposits of the inner basins.

- (b) compartmentalisation by transverse contemporaneous uplifts; and
- (c) progressive abandonment of the sedimentary relationship with the Duero Basin, due to capture by the Portuguese fluvial network.

The oldest sedimentary rocks found in the western Duero Basin are the Cretaceous to Palaeocene *siderolithic* series (Jiménez, 1970, 1977; Blanco *et al.*, 1982; Molina *et al.*, 1989), which crop out only in the easternmost Ciudad Rodrigo Basin. These sediments are petrologically and mineralogically mature (quartz and kaolinite). Silcretes and ferricretes are abundant (Corrochano, 1977; Bustillo & Martín-Serrano, 1980; Blanco & Cantano, 1983).

The larger part of the sedimentary record is of Middle-Late Palaeocene age and it can be divided into three units of arkosic composition:

- The lower one (Early Eocene?) crops out to the north of

		SALAMANCA		ZAMORA		CIUDAD RODRIGO BASIN		
		1	2	3	4	5	6	7
MIOCENE	Upper				Ochre Series		Caboziela	
	Middle			Tierra de Campos Facies			Conglomerates	
	Lower	Cilloruelo Red Conglomerates	Armuña Conglomerates	Mirazamora Facies	Red Series			Variegated Conglomerates
OLIGOCENE		Molino del Pico Sandstones	Molino Sandstones	Upper Detritic Unit	Bellver Conglomerates & Sandstones (Upper Group)		Alamedilla	Upper Arkosic Unit
		Mollorido Sandst.	Aldearrubia Sandstones	Cubillos Limest.			Arkoses	
		Aldearrubia Sandst.						
EOCENE		Cabreros Sandst.	Cabreros Sandstones	Clayey Unit	Yellow Silts (Lower Group)	Ciudad Rodrigo Series	Ciudad Rodrigo Formation	Lower Arkosic Unit
		Villamayor Sandst.				Tejoneras Series		
PALEOCENE		Rfo Almar Sandst.	Arapiles Conglom.	Zamora Facies	Zamora Facies			
		Salamanca Sandst.	Peña Celestina Mudst.					
		Amatos Sandst.	Terradillos Sandst.	Montamarta Facies	Montamarta Facies			
CRETACEOUS		Lower Conglomerate	Peña de Hierro Bed	Ferrilitic Crust	Ferruginous Crust			

Fig. 2. Various stratigraphic sections proposed for the Palaeogene deposits of Salamanca and Zamora provinces by previous workers (after Santisteban *et al.*, 1991). 1: Jiménez (1970); 2: Alonso Gavilán (1981); 3: Corrochano (1977); 4: Martín-Serrano (1988); 5: Jiménez & Martín-Izard (1987); 6: Alonso Gavilán & Polo (1986-87) and Alonso Gavilán & Cantano (1987); 7: Cantano & Molina (1987).

Ciudad Rodrigo (Tejoneras Series; Jiménez & Martín-Izard, 1987), resting unconformably upon the *siderolithic* series of Salamanca (Santisteban *et al.*, 1991). It consists of white arkoses with variegated spots; grain size varies widely. This unit was deposited in proximal braided river systems.

- The Middle Eocene (Jiménez, 1977, 1982) intermediate unit crops out in many places with a thickness of up to 100 m both in Ciudad Rodrigo and in the SW Duero Basins (Figs. 2 and 3). It is composed of beige-greenish or reddish arkosic to lithoarkosic sandstone and mud, forming a coarsening-upwards megasequence. The muds are burrowed and hardened (calcretes and silcretes). They are interpreted as deposits of braided to sinuous fluvial systems that flowed towards the east and north-east and had well-developed flood plains.
- The third, Oligocene (Cantano & Molina, 1987, Polo *et al.*, 1987), unit is composed of coarse-grained arkoses with idiomorphic large-sized feldspars. They are rich in smectitic clays and show a little cementation. This unit reaches more than extensive.

Neogene sediments of presumed Early-Middle Miocene age are represented in the eastern Duero Basin, forming a gently dipping piedmont that erodes and buries the Palaeogene deposits. The age is based on detailed stratigraphical correlation. They are polymictic, heterometric red conglomerates deposited in alluvial cones passing distally into red sands and muds with paludal and pedogenic (edaphic) carbonates. The youngest deposits are Upper Miocene-Pliocene siliciclastic, ochre sediments deposited in alluvial plains of similar appearance to those of *rañas* related to the initiation of fluvial dissection (Mediavilla).

The *Alagón basins* are morphostructural and stratigraphic copies of the Ciudad Rodrigo Basin. Thickness reaches 900 m in the Coria Basin. For instance, the Moraleja-Castelo Branco Basin is a half-graben lowered towards the NW by the Ponsul Fault (Dias & Cabral, 1989). All these small basins are the remains of a single, larger basin that underwent faulting and erosion (Fig. 4). As a consequence they all show the same lithofacies (Bascones & Martín Herrero, 1982a, b; Bascones *et al.*, 1982a, b, 1984a, 1984b; Ugidos *et al.*, 1985). The most prominent

- The major part of their sedimentary fill consists of fluvio-lacustrine arkoses, subdivided into two litho-

		UNITS	LITHOSTRATIGRAPH	THICKNESS (m.)	FOSSILS	PALEOCURRENTS	SEQUENCES	BOUNDARIES & ALTERATIONS	TECTONIC STAGES
TERTIARY	PLIOCENE	Ochre Series		2-35	6			Ochre alteration	
		Weld-Upp. Series						Discordance	Storic I
	MIOCENE	Red Series		2-50	5			Red alteration	
		Lower						Discordance	Saovic
	OLIGOCENE	TSU P3		20-120	4			Discordance	Pyrenean
		Upper							
	Eocene	TSU P2		30-100	3				
		Middle							
	Lower	TSU P1		2-40	1			Discordance Dolomitic crust	Pre-Pyr.
								Discordance Silicification	Neo-Lar.
PALEOCENE		TSU		3-70	0			Discordance Lotic alteration	Laramic
CRETACEOUS		MC							
PALEOZOIC									

Fig. 3. Stratigraphic section of Paleogene deposits in the south-western Duero Basin (after Santisteban *et al.*, 1991). O: Absolute age (K/Ar) 58 Ma (Blanco *et al.*, 1982), 1: Sanzoles and Avedillo (Zamora), 2: Teso de la Flecha (Salamanca) and Corrales (Zamora), 3: Molino del Pico and San Morales (Salamanca), 4: Camino Fuentes and El Molino (Ciudad Rodrigo Basin), 5: El Guljo (Salamanca), 6: Benavente (Zamora).

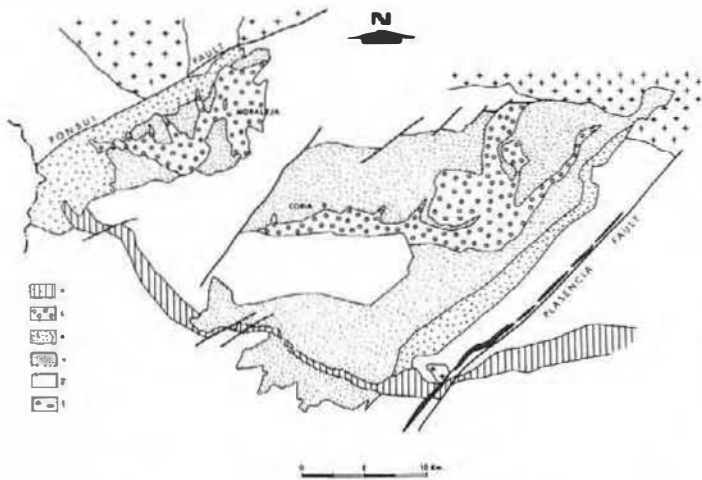


Fig. 4. Sedimentary infill of Alagón, Coria and Moraleja basins (adapted from Bascones *et al.*, 1982b, 1984a, b, c). 1. igneous rocks; 2. schists; 3. quartzites; 4 and 5, Tertiary (4 fluviolacustrine arkoses; 5, coarse grained sediments of the marginal fringes); 6. recent deposits related to fluvial network.

facies: 1. white-grey and ochre gravelly sands and polymictic micro conglomerates indurated by carbonates and clays; this lithofacies dominates the sedimentary fill; 2. grey, green and brown muddy sands, burrowed smectitic muds and sands in channel-form bodies with carbonate concretions and fish bones (Clupeidae).

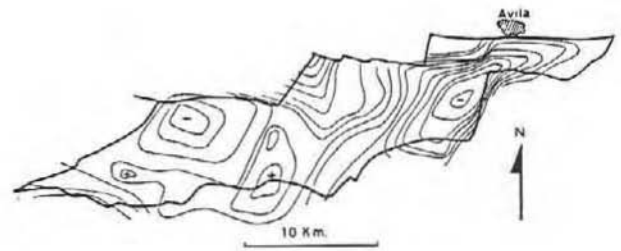


Fig. 5. Maps of structural and Bouguer anomalies of Amblés Basin (Carzon *et al.*, 1981). 1: Tertiary sediments; 2: Hercynian basement; 3: fault; 4: buried fault.

– Along the faults bounding the basins there are marginal ribbons of red muds and reddened polymictic conglomerates.

The largest part of the sedimentary fill of the Ciudad Rodrigo Basin is attributed to an Eocene-Oligocene age on the basis of detailed stratigraphic correlation with the area of Salamanca and Zamora, coupled with palynological dating. Stratigraphic and morphostructural similarities between the Ciudad Rodrigo Basin and the basins placed towards the south, support the extension of this correlation to their arkosic sediments. Tertiary sediments, mainly of Palaeogene age, should be present at both margins of the Central mountain range in the two tectonically controlled, subsiding troughs filled with fluvial sediments.

Internal basins of the eastern area

Small, discontinuous basins occur in an ENE WSW direction for more than 150 km in the Gredos-Guadarrama-Somosierra massif. Such basins are affected and displaced by E-W and NE-SW faults. The most important of these small basins are the Amblés and Campo Azálvaro basins, where sedimentation reached thicknesses of 1000 and 400 m of sediments respectively (Fig. 5).

Eastward from Avila, basins contain siliciclastic and carbonate sediments of Late Cretaceous age. *Siderolithic facies sensu stricto* are restricted to Campo Azálvaro, Amblés and Alto Alberche basins. However, the sedimentary infill of these basins began with

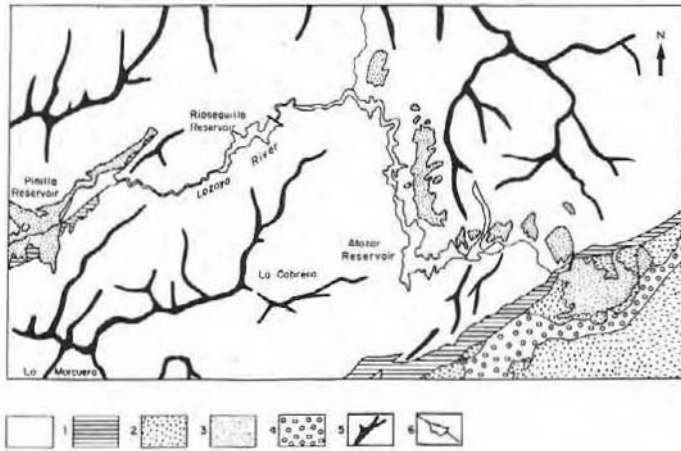


Fig. 6. Tertiary deposits related to the Lozoya River. Unshaded, substratum. 1. Mesozoic deposits of the Central System. 2. Tertiary deposits of the Madrid Basin. 3. Tertiary deposits related to the Lozoya River. 4. Jarama River's alluvium. 5. Main mountain divides. 6. Reservoirs.

arkoses containing Cretaceous rock fragments in the lower part. Stratigraphic correlation and palaeontological data from Los Barros (Amblés Valley) (Garzón & López, 1978) indicate a Middle-Late Palaeogene age for these sediments. This arkosic unit forms a fining-upwards megasequence composed of conglomerates with carbonate cement, arkosic sands and muds with caliches (carbonate-palygorskite-sepiolite)

river environments. The palaeocurrent direction is opposite to the present regional morpho-structure (Martín-Serrano & del Olmo, 1990b; del Olmo, 1990a; Martínez Salanueva & del Olmo, 1990).

Sediments of possible Neogene age are coarse-grained arkoses forming two megasequences with a restricted and incomplete areal distribution. Those of Early-Middle Miocene age are very coarse-grained sediments (conglomerates with boulders and sands with hydromorphic and edaphic features) with grain-size decreasing rapidly distally. They form a fining-upwards megasequence composed of alluvial-fan braided river sequences in concordance with the present morpho-structure. They form the morphological top of the basin infill (Martín-Serrano & del Olmo, 1990b; del Olmo, 1990a, b, 1991). Upper Neogene sediments are siliciclastic, of fluvial origin, and only represented in a few outcrops (Martín-Serrano & del Olmo, 1990b; de Olmo, 1990b, 1991), apparently related to the present fluvial network (Fig. 6).

The generation of the basins is related to post-Intra-Oligocene movements of N10–30° E and N60–100° E fault systems (*Iberian Stage*), and their Palaeogene arkosic infill (and locally also the Neogene) is affected by reverse or strike-slip faults N20–40° E and N75° E that define their borders (Capote *et al.*, 1987, 1990a, b, c, d, 1991; de Vicente, 1988).

Morphostructural evolution and sedimentary infill

The rise of the Central System is related to Alpine reactivation of Late Hercynian fault systems. The evolution of these

movements directly affected the basins, and the sedimentary record is the essential key to understanding the tectonic and palaeomorphological history of the Central Range (and vice versa). The evolution of the Central System is deduced from the sediments found in nearby areas (pre-arkosic, arkosic and postarkosic stages; Garzón *et al.*, 1982), because the division links the filling of the basins with the definition of the mountain range.

Until the Upper Palaeogene (Middle-Late Eocene in Salamanca; Eocene-Oligocene in the Gredos-Guadarrama) a mature relief was developed (*superficie poligénica fundamental*) with smooth residual lineaments of Hercynian strike as in Peña de Francia, Tamames... (Pedraza, 1978; Garzón, 1980; Martín-Serrano, 1988; Fernández, 1988). The *siderolithic* or *siliceous sandstones* of Zamora and Salamanca (Jiménez, 1970; Corrochano, 1977; Bustillo & Martín-Serrano, 1980; Alonso Gavilán, 1981; Martín-Serrano, 1988), *Lower Tertiary Unit* (Garzón, 1980; Garzón *et al.*, 1981) or *pre-arkosic cycle* (Pedraza, 1978; Garzón *et al.*, 1982) of the Avila basins, are related to the Cretaceous sediments found west of the Campo Azálvaro meridian (Garzón *et al.*, 1982; Martín-Serrano & del Olmo, 1990a; Molina *et al.*, 1989), which, in the easternmost areas of the range, are interbedded with marine Cretaceous carbonates (Alonso, 1981).

All the Mesozoic siliciclastic lithofacies (*Utrillas, Weald*...) include alterite debris. The lack of carbonate fragments in the Palaeocene or pre-Lutetian and/or Cretaceous pre-arkosic sediments implies Cretaceous shelf preservation. Intensely weathered areas without Mesozoic sediments remained as source areas. Central System uplift did not take place during this episode (Martín-Serrano & del Olmo, 1990b).

The dispersion, isolation and deformation suffered by the outcrops of *siderolithic* rocks located close to mechanically deformed basin borders and their absence in the western basins support the previous arguments. Their sedimentation area is bounded by a line oblique to the range but parallel to the maximum extent of marine Cretaceous sediments (Fig. 7).

The uplift of the mountain ranges started from a Mesozoic inheritance: a smooth relief acting as source area of the pre-Lutetian continental deposits.

Morphostructural reorganisation of the area started with the *Arkosic cycle*. Its deposits rest unconformably upon Cretaceous sediments in the eastern basins. The lowermost arkosic sediments, near the bottom of the basins, include abundant rock fragments derived from Mesozoic outcrops. The rapid transition from these sediments (rich in fragments of granite and carbonate rocks) to those of exclusively arkosic nature suggests limited erosion of Cretaceous sediments and a slow areal uplift. The source area must have been a non-altered substratum.

No Cretaceous sediments have been found in the western basins; however, it is not difficult to deduce the age of uplift of the mountains. Near Salamanca, arkoses *sensu lato* fossilise an irregular, faulted substratum of Palaeozoic and *siderolithic* rocks. Fault directions are N30, N120 and E-W. As in the Amblés and Campo Azálvaro

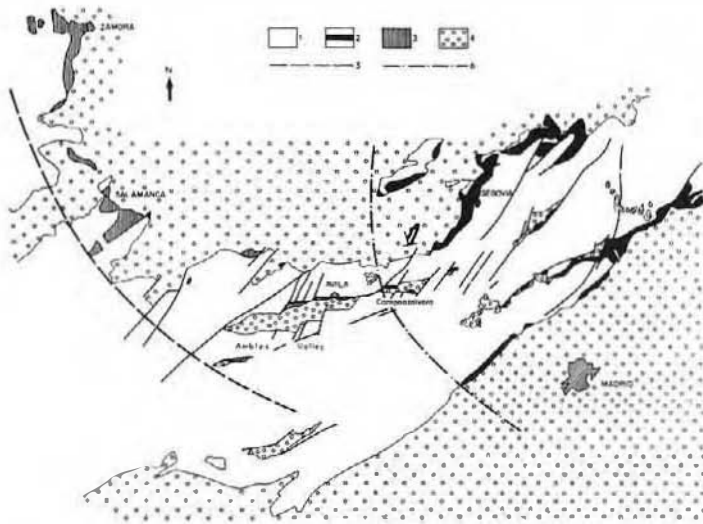


Fig. 7. Main outcrops of *siderolithic* facies and carbonate marine sediments of Cretaceous age of Central System. Probable limit of sedimentation. 1, basement; 2, Cretaceous marine sediments; 3, *siderolithic* facies; 4, Tertiary continental sediments; 5, marine sedimentation edge; 6, *siderolithic* sedimentation edge.

mineralogy between the *siderolithic* facies (of mature composition: quartz, quartzite and kaolinite) and the arkosic unit (rich in feldspar, neoformed smectites and labile minerals and rock fragments derived from metamorphic source areas) is easily observed. Non-granite fragments characterise the deposits of the western basins made up of interbedded more-or-less arkosic lithofacies.

The extent of the sedimentary basin during the Middle-Late Palaeogene in the western sector was much wider than the area of the present basins. There are several arguments:

- The lithofacies of the Ciudad Rodrigo Basin and the Alagón basins are very similar.
- As most of the basin fills are fine grained it can be assumed that environments were geographically extensive and surrounded by topographically smooth areas (plains).
- All the basins exhibit the same sequential evolution.

Moreover, the palaeocurrent patterns do not conform to the present morphology of the basins. All this supports the conclusion that the arkosic stage did not result from the morphological evolution of the Central System into basins and ranges (Garzón *et al.*, 1982). The lithologies of the Palaeogene sediments of the Ciudad Rodrigo or Alagón basins (burrowed smectitic muds of fluvio-lacustrine origin with fish remains) point to slow subsidence and open, flat landscapes instead of rapid orographic reorganisation. Such an environmental context is very different from the present; this is supported by the fact that tectofacies related to faults bounding the basins are present only in the latest stages of basin infill. At that stage, there was concordance between the sedimentary record and its morphostructural context. How was the *Iberian phase* (Oligocene–Early Miocene) recorded in the marginal tectofa-

cies? Moreover, was it related to the coarsening-upwards trend of the arkosic unit *sensu lato* of these western basins? Tectofacies of the Gredos, Guadarrama and Somosierra are attributed to the *Guadarrama stage* (Intra-Aragonian), a tectonic phase connected to compression of the Betic Cordillera that caused the present pattern of the Central System and deposition of relatively thick alluvial-fan sediments by large alluvial cones at the top of most of the basin fills. These may be of the same age as the red alluvial-fan deposits of eastern Ciudad Rodrigo Basin, but their relationship with the coarser lithofacies topping the sedimentary infill of the Alagón basins is unclear. Both tectofacies may be coeval (synchronous) but they may also be two well-differentiated stages recorded along the whole Central System.

It is difficult to maintain that the arkosic stage continued through the Late Tertiary to end in Middle Pliocene times with the deposition of the *Parámos*

(1982). The arkoses of the Central System are of Eocene–Oligocene age and the highest alluvial-fan deposits may be of Aragonian age (Martín-Serrano & del Olmo, 1990b; del Olmo, 1990a, b, 1991). There is only a poor record of the remaining Tertiary and Quaternary sediments because of the active river incision at that time in the basins, the ranges and elsewhere in the Spanish Meseta (Martín-Serrano, 1991).

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