

The alluvial to palustrine-lacustrine Miocene sequence from the Faido-Samiano section (Miranda – Treviño basin, W Pyrenees)

La secuencia aluvial a palustre-lacustre del Mioceno de Faido-Samiano (cuenca Miranda – Treviño, Pirineos occidentales)

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ABSTRACT

This work presents the results from the study of the lower to middle? Miocene continental succession exposed in the Faido-Samiano section, on the south-east flank of the Miranda – Treviño piggy-back basin. Facies analysis allowed accurate interpretation of the constituent deposits and the corresponding depositional settings they characterize, from alluvial to varied palustrine-lacustrine sub-environments. Logging and mapping across an area of about 15 km² revealed a distinct recurrent stratigraphic arrangement that reflects successive cycles of progressive expansion and abrupt subsequent retraction of the km-wide palustrine-lacustrine wetlands developed on the basin depocentre. The scale and distinct asymmetry of the successive stratigraphic cycles point to an origin likely related to high-frequency pulsating tectonic activity affecting the rising basin margins.

Key-words: *Miranda – Treviño basin, palustrine-lacustrine facies, alluvial fan, lower Miocene.*

RESUMEN

Este trabajo expone los resultados del estudio de la sucesión continental del Mioceno inferior-medio? aflorante en la sección de Faido-Samiano, en el flanco sureste de la cuenca piggy-back de Miranda-Treviño. El análisis de facies ha conducido a la interpretación de un sistema sedimentario integrado por ambientes de abanico aluvial, palustre y lacustre. El levantamiento de la sección estratigráfica y la cartografía de los diferentes tramos ha permitido reconocer un patrón de facies recurrente, que refleja varios ciclos de expansión progresiva y retracción brusca de los humedales palustres-lacustres desarrollados en el centro de la cuenca. La escala y la asimetría de estos ciclos estratigráficos se ha relacionado con pulsos tectónicos de alta frecuencia afectando a los márgenes activos de la cuenca.

Palabras clave: *Cuenca Miranda – Treviño, facies palustres-lacustres, abanicos aluviales, Mioceno inferior.*

Geogaceta, 66 (2019), 27-30
ISSN (versión impresa): 0213-683X
ISSN (Internet): 2173-6545

Recepción: 31 de enero de 2019
Revisión: 25 de abril de 2019
Aceptación: 24 de mayo de 2019

Introduction

Extensive palustrine-lacustrine carbonates deposited in hard-water wetlands and shallow lakes were common during the Miocene in different continental areas of Iberia such as the Ebro, Duero and Madrid basins (Alonso-Zarza *et al.*, 1992; Arenas and Pardo, 1999; Armenteros *et al.*, 2002). These continental carbonates have provided valuable facies models and record distinct phases of water level changes and lake-wetland expansion-retraction usually ascribed to short- and long-term climatic changes. Similar carbonates also developed in other tecto-sedimentary contexts, including several Miocene piggy-back sags along the Pyrenean orogenic belt. Here we document the facies analysis carried out in

the Miocene carbonate succession from the Faido-Samiano section, in the Miranda-Treviño basin.

Geological setting

The Miranda – Treviño basin is located in the southern Basque – Cantabrian region, the western prolongation of the Pyrenean orogen. During the Neogene it evolved as an endorheic piggy-back syncline basin that extended east-west for about 30-40 km, northwards of the emerging Sierra de Cantabria-Montes Obarenes thrust sheet. The basin overlies tilted and folded Mesozoic-Paleogene marine rocks and was filled asymmetrically by up to 3000 m of continental clastic and carbonate deposits (Riba, 1956, 1961; Martín Alafont *et al.*,

1978). Two main stratigraphic sequences separated by an angular unconformity form the sedimentary infill, respectively ascribed to the Oligocene and early to middle? Miocene (Martín Alafont *et al.*, 1978). The upper sequence is the most extensive and at a larger scale consists of two main intergradational sediment packages: coarse clastics along the northern margins and fine-grained carbonates and siliciclastics across the southern basin depocentre.

The Faido-Samiano section (Fig. 1) is located on the southeast flank of the basin and exposes in relative continuity up to 250 m of lower Miocene alluvial to palustrine-lacustrine deposits. This succession lies directly onto tilted Cretaceous-Paleogene rocks and, from base to top, consists of calcareous conglomerates evolving to al-

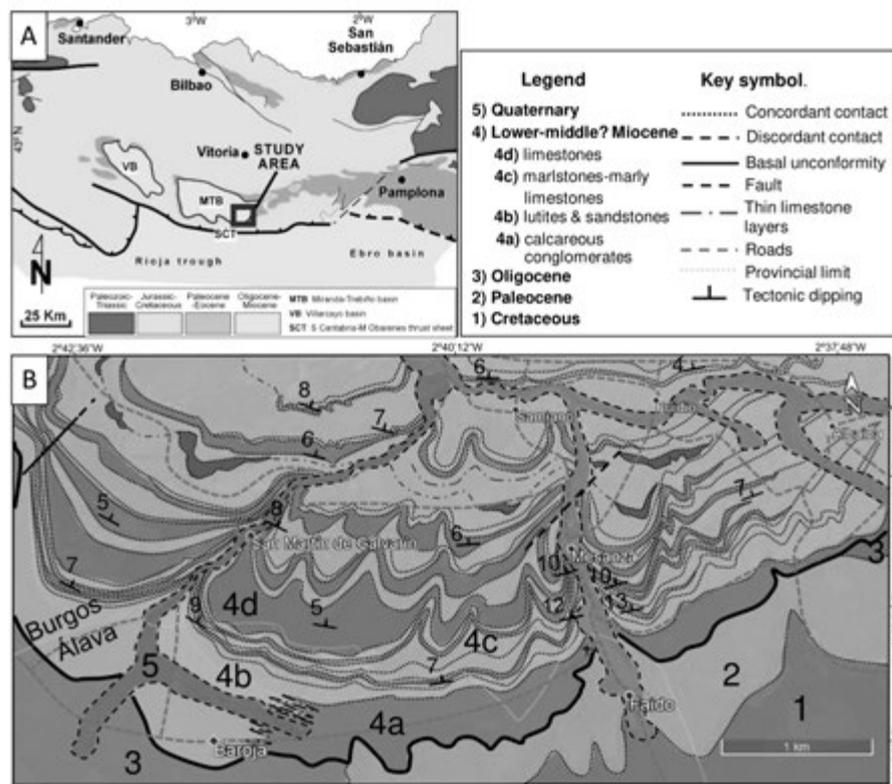


Fig. 1.- A) Location of the study area in the Basque-Cantabrian Basin. B) Geological map of the Faido-Samiano study area, on the southeast flank of the Miranda - Treviño basin. See color figure in the web.

Fig. 1.- A) Localización del área de estudio en la Cuenca Vasco-Cantábrica. B) Mapa geológico del área de estudio Faido-Samiano, en el flanco sureste de la Cuenca de Miranda-Treviño. Ver figura en color en la web.

ternating limestones, marlstones and lutites, with interspersed sandstone bodies (Figs. 1 and 2).

Facies analysis

Four main facies associations (FA1 to FA4) have been distinguished in the Faido-Samiano section, each one comprising several distinct lithofacies (F1a to F4d, see below).

Calcareous conglomerates and sandstones (FA1)

This facies association forms the basal 10-25 m part of the section, but towards the east and north-east it thickens progressively being dominant in the Miocene sequence. The main lithofacies are massive beds of grain-supported conglomerates (F1a) of highly variable grain size (average size 5-20 cm) and subspherical to subangular. The lithoclasts were eroded from the different Cretaceous-Palaeogene units of the substrate (Paleocene dolostones and coralgal limestones, Eocene *Alveolina*-rich limestones and Campanian-Maastrichtian

(*Orbitoides*-rich calcarenites and sandstones). Individual beds have erosive bases and range 1-5 m in thickness. Internally, the conglomerates are massive or exhibit crude stratification and normal grading. Discontinuous beds of laminated to cross-bedded medium to coarse-grained lithic arenites (F1b) are subordinate facies in the conglomerate suite, which vertically and distally grades to deposits of FA2.

Lutites and ribbon sandstones (FA2)

This facies association forms several 5-15 m-thick intervals of soft recessive strata. The bulk sediment is reddish to dark brown lutites (F2a), massive or with crude lamination. At different intervals, these lutites intercalate discontinuous cm-thick levels rich in iron oxide impregnations, irregular rhizoliths and, eventually, nodular micritic carbonate (F2b, Fig. 3B).

dm- to m-thick light brown to yellowish lithic arenites (ribbon sandstones, F2c) occur randomly interspersed between the lutites. They occur either as individual tabular to lenticular bodies or multi-episodic store-

yed bodies that laterally extend for several 10's of meters, with prominent erosive base and characteristic thinning-finning up arrangement. Single beds are massive or laminated, and commonly occur capped by ripple-laminated silt-clayey sediment. Parallel and cross lamination and bedding are widespread, commonly distorted by early soft deformation. The sandstones are mixed in composition, with variable amounts of quartz and lithic carbonate grains, including reworked Cretaceous and Palaeogene bioclasts.

Marlstones and nodular marly limestone (FA3)

These deposits are easy to distinguish from the F2a lutite intervals by their grey-whitish colorations and different sedimentary characteristics. The marlstones (F3a) are dominant and form m-thick packages with crude horizontal lamination. Washed residues from some samples provided remains of broken ostracods and charophytes.

Interbedded with the marlstones there occur dm- to m-thick intervals of more indurated nodular marly limestones (F3b), usually of reddish mottled colours. Irregular cracks, nodulization and alveolar structures (cf. Alonso-Zarza and Wright, 2010) are common features seen in thin section. Laterally, these facies show very irregular distribution.

Limestones (FA4)

These are well-stratified deposits either forming tabular single beds or 3-6 m thick packages that extend laterally from 0.5 km to more than 3 km. Different lithofacies can be identified. The most common are massive to crumbly limestones (F4a) that under the microscope show abundant peloids and intraclasts within a clotted micrite matrix (Fig. 3C). They contain sparse fragments of ostracods, charophytes and eventually tiny gastropods. Individual beds occur separated by laminated marly interbeds (F4b) with a similar microfossil content. Some tops of F4a lithofacies exhibit (Fig. 3D) vertical root cavities, intraclasts concentrations, dessiccation cracks and incipient brecciation, with most voids and cracks infilled geopetally by crystal silt to sparry limpid calcite. Locally, some beds also show internal erosive surfaces and channels, floored by thin graded

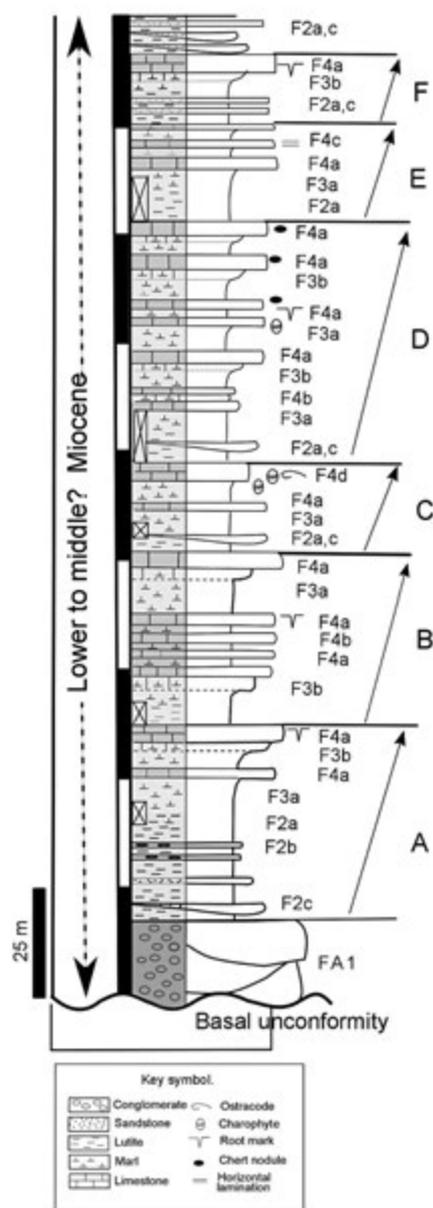


Fig. 2.- General stratigraphic log of the study area showing the vertical succession of sedimentary facies. A to F refer to the different palustrine to lacustrine cycles. See color figure in the web.

Fig. 2.- Columna estratigráfica general del área de estudio que muestra la sucesión vertical de facies sedimentarias. A a F corresponden a los diferentes ciclos de facies palustre-lacustre identificados. Ver figura en color en la web.

peloidal grainstone-packstones (F4c, Fig. 3E). Tabular, massive to laminated fine-grained limestones (F4d) characterize the upper part of some limestone packages. They are unsorted biomicrites with sparse ostracod and charophyte remains (Fig. 3F). Locally, they also contain bioturbated layers of fine to very fine grainstone-packstones with parallel and cross lamination. These limestones rarely exhibit desiccation features. A distinct diagenetic feature in all limestone facies

from FA4 is the presence of chert nodules of uncertain origin, which occur bedding aligned and forming stratiform levels.

Facies model

According to their characteristics and spatial relationships, the studied Miocene deposits define a facies continuum of different depositional (sub) environments (Fig. 3).

The conglomerates and sandstones of FA1 are interpreted as deposits from mass flows and high-energy channelized tractive currents, characteristic of proximal alluvial fan settings. These coarse facies intergrade with the lutite and ribbon sandstone packages of the FA2, which likely represent the distal alluvial fan fringes, with muddy floodplains dissected by ephemeral fluvial channels. The interspersed thin and discontinuous iron-rich intervals with rhizoliths and nodular carbonate can record incipient development of calcrete paleosols (Alonso-Zarza and Wright, 2010).

In lateral and vertical continuity, the alluvial-fluvial succession grade and interfinger with the carbonate deposits of FA3 and FA4. The marlstone intervals are interpreted as facies deposited in water-logged to very shallow aquatic settings that evolved under alternating wet and dry conditions, with episodes of plant colonization, partial exposure and subsequent re-flooding, typical of palustrine settings (Alonso-Zarza and Wright, 2010).

Finally, the different limestone facies grouped in the FA4 would represent shallow semi-permanent palustrine to lacustrine settings, including from littoral vegetated patches separated by plant-free corridors and channels, to open areas with deposition of fine carbonate and microfossil remains, disturbed by bioturbation and episodic turbulence (Hernández, 2000).

Stratigraphic arrangement

The complex vertical succession of facies is one of the most striking features of the studied Miocene sequence. At the larger scale, it is made up of alluvial facies that vertically evolve to palustrine-lacustrine carbonates. This trend evidences a phase of progressive alluvial fan retrogradation towards the north and northeast, and the coeval expansion of the central lacustrine-palustrine wetlands. This pattern

follows the general stratigraphic arrangement established in previous works for the whole Oligocene-Miocene megasequence that infills the Miranda-Treviño basin in north-south sections, with a progressive onlap and northwards migration of the successive basin depocentres in response to the emplacement of the Sierra de Cantabria-Montes Obarenes thrust sheet (Riba, 1956; Riba and Jurado, 1992).

At smaller scale, the general sedimentary trend was punctuated by higher-frequency facies changes that allow the differentiation of six successive asymmetric cycles (A to F in Fig. 2). Although with significant differences, each cycle begins with alluvial clastic deposits that grade progressively into palustrine-lacustrine carbonates, with the topmost interval usually defined by those carbonates characterizing the “deeper” depositional conditions. The upper cycle boundaries are always abrupt, marked by a sudden recurrence of alluvial deposits. Through mapping, the seven cycles demonstrate to have continuity along the whole study area and some even extend further west for no less than 5-7 km. By analogy to other Miocene basins, these cycles could reflect climatic changes, although based on their scale and distinct asymmetry, they may rather respond to short-term tectonic pulses affecting the basin and the rates of detrital supply from the marginal Cretaceous-Paleogene source areas.

Conclusions

The study of the lower to middle? Miocene from the Faido-Samiano section has evidenced a complex cyclical succession of clastic and carbonate sediments. Among them, a wide range of carbonates of palustrine-lacustrine nature have been distinguished, representative of ephemeral km-wide wetlands that likely expanded and retreated in response to intrabasinal tectonic pulses. Further research is needed on this sedimentary succession, particularly to temporally constraint it with detailed age dating (*i.e.*, bio- and magnetostratigraphy), and to build a more detailed stratigraphic framework for the whole Miocene series exposed across the Miranda-Treviño basin.

Acknowledgements

This is a contribution to the Basque Country Research Group IT930-16. Z. L. acknowledges funding from the Dpt. of

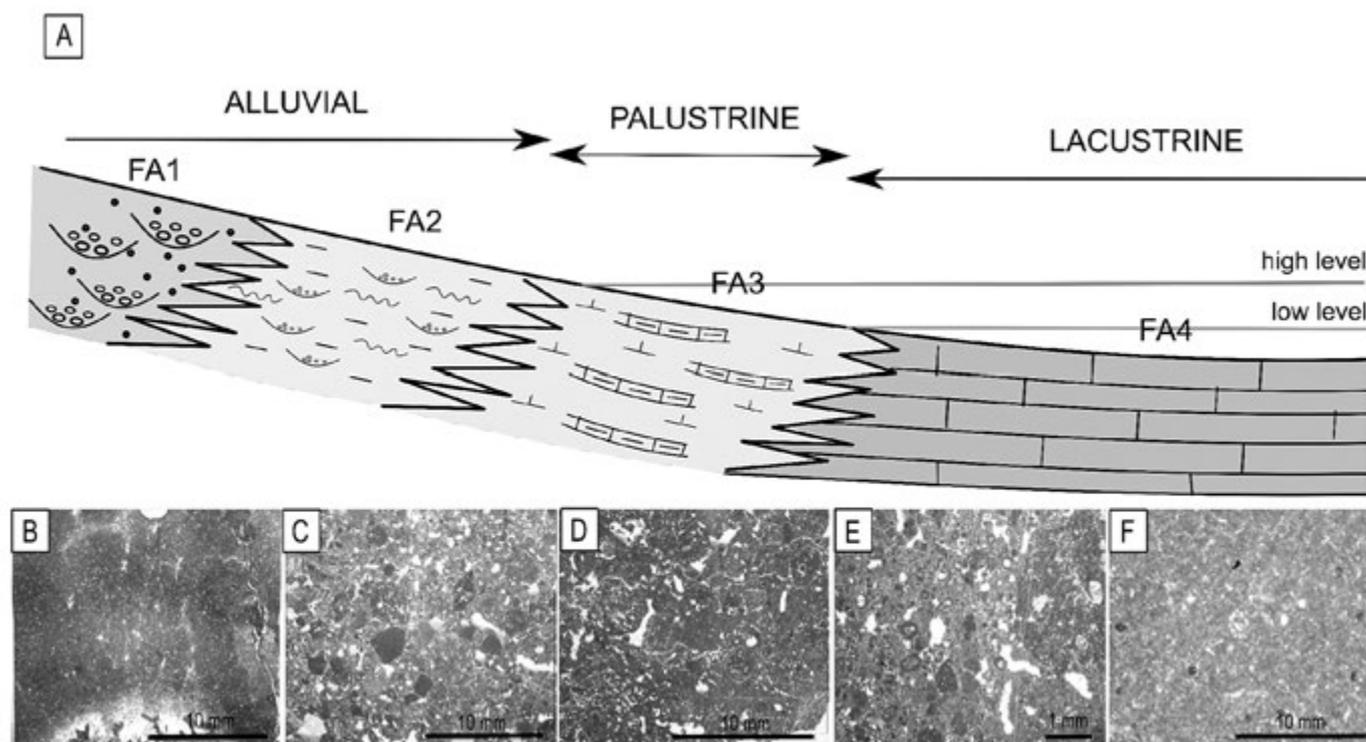


Fig. 3.- A) General facies model. B-F) Representative limestone microfacies. B) Nodular micrite carbonate with Fe-oxide disseminations (Facies 2b). C) Crumbly limestone with intraclasts (Facies 4a). D) Crumbly limestone with desiccation cracks and crystal silt to limpid calcite geopetal fills (Facies 4a). E) Graded peloidal grain-packstones (Facies 4c). F) Fine-grained limestones with sparse bioclasts (Facies 4d). See color figure in the web.

Fig. 3.- A) Modelo de facies general. B-F) Microfacies carbonatadas representativas. B) Carbonato micrítico-nodular con diseminaciones de óxidos de Fe (Facies 2b). C) Caliza "crumbly" con intraclastos (Facies 4a). D) Caliza "crumbly" con grietas de desecación y rellenos geopetales de crystal silt-calcita (Facies 4a). E) Grain-packstone peloidales gradados (Facies 4c). F) Caliza de grano fino con bioclastos dispersos (Facies 4d). Ver figura en color en la web.

Education and Research of the Basque Government through a grant from the Programme of Collaborative Research for last year Degree students. Comments from reviewers C. Arenas and I. Armenteros, improved considerably the final version of this manuscript.

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