[PS]The Tertiary Geological Record of the Bureba Area, Western Ebro Basin, Spain*

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Abstract

During the Tertiary, from the Late Eocene to the Miocene, the Ebro Basin, situated at the northeastern part of Spain, became a non-marine basin where diverse lacustrine evaporitic systems developed. Diverse alluvial and fluvial systems were originated in the marginal areas (Iberian chain to the south and Cantabrian Mountains and Pyrenees to the north). These systems advanced towards the center of the basin. The excellent preservation and outcrop continuity from the northern to the southern margins permit to literally walk along the lateral contact and facies changes from the alluvial and/or fluvial systems into the lacustrine evaporitic deposits. Bed-by bed sections measurements, petrographic and geochemical analyses of samples as well as the establishment of the depositional framework of the different architectural elements permit to determine that the main factors that controlled the vertical and lateral facies arrangements appear to be the paleoclimatic conditions and lithologic composition of the source area, among other factors such as the slope of the depositional surfaces and the size of the catchment area have a less important impact.

The study is focused in the western part of the Ebro basin, in the area called La Bureba Corridor that connects the Ebro and Duero basins. The detailed analyses of the interrelationships permit to develop a model of the geologic evolution of this part of the Ebro Basin in Tertiary times. The resultant dataset permits to establish an outcrop analogue model as well as characterize geometry and architectural arrangements of lacustrine facies associations and their correlative marginal detrital deposits.

The Tertiary Geological Record of the Bureba Area, Western Ebro Basin, Spain

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ABSTRACT: During the Tertiary, from the Late Eocene to the Miocene, the Ebro Basin, situated at the northeastern part of Spain, became a non-marine basin where diverse lacustrine evaporitic systems developed. Diverse alluvial and fluvial systems were originated in the marginal areas (Iberian chain to the south and Cantabrian Mountains and Pyrenees to the north). These systems advanced towards the center of the basin. The excellent preservation and outcrop continuity from the northern to the southern margins permit to literally walk along the lateral contact and facies changes from the alluvial and/or fluvial systems into the lacustrine evaporitic deposits. Bed-by bed sections measurements, petrographic and geochemical analyses of samples as well as the establishment of the depositional framework of the different architectural elements permit to determine that the main factors that controlled the vertical and lateral facies arrangements appear to be the paleoclimatic conditions and lithologic composition of the source area, among other factors such as the slope of the depositional surfaces and the size of the catchment area have a less important impact. The study is focused in the western part of the Ebro basin, in the area called La Bureba Corridor that connects the Ebro and Duero basins. The detailed analyses of the interrelationships permit to develop a model of the geologic evolution of this part of the Ebro Basin in Tertiary times. The resultant dataset permits to establish an outcrop analogue model as well as characterize geometry and architectural arrangements of lacustrine facies associations and their correlative marginal detrital deposits.

1. INTRODUCTION

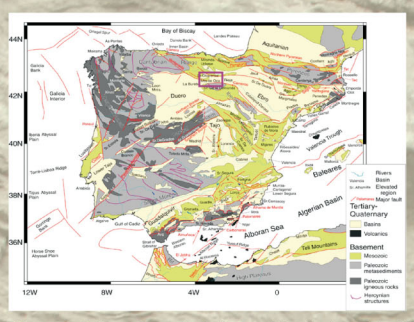

Figure 1: Schematic geological map of the Iberia and the Western Mediterranean region. Note the Ebro Basin bounded by the Pyrenees to the NE, The Cantabrian Range to the N and the Iberian Range with the Sierra Demanda to the S and SE. The purple rectangle indicates the studied area (Modified from Andeweg, 2002.

The Ebro basin is located in the north-eastern part of the Iberian Peninsula. It's a triangular shaped basin, with the Ebro basin flowing from East to west. Its shape is due to the mountain chains at its edges: the Catalan coastal chain to the East, the Iberian chain to the south and the Pyrenees to the north. Towards the west it is in partial contact with the Duero basin through the Bureba Corridor (Fig.1). The Ebro Basin was formed during the upper Oligocene-lower Miocene (Fig. 2). It was formed as a consequence of the onset of the Alpine orogeny. With the uplift of the Pyrenean chain, several thrusting sheets prograded towards the south. The main factors controlling the sedimentary evolution were the tectonic uplift and the folding of the basin margins.

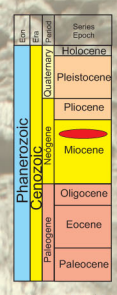

Figure 2: Geological Timescale

GEOLOGICAL SETTING

The northern limb, the Montes Obarenes and the Sierra Cantabria range are southward directed thrust unit which form part of the westernmost Pyrenean thrust belt. The southern margins is bounded by the Demanda-Cameros ranges, with northward directed thrusts at the western limit of the Iberian Chain. The original extent of the Rioja Basin was much larger prior to thrusting. To the west the basin is limited by the Atapuerca Sierra. Major thrusting along northern and southern margins are responsibles for the reduction of the extension of the original basin in the order of 70% (Fig. 3).

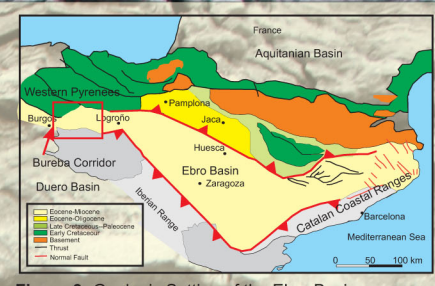

Figure 3: Geologic Setting of the Ebro Basin

The Obarenes and Cantabrian Sierras separate the marine Paleogene-Eocene deposits of the north and the lacustrine continental ones from the south. Most of the Tertiary sedimentation was formed under sintectonic conditions. The Ebro basin had two main source areas of material, one from the north, and another one from the south. The Miocene continental units (Fm Najera y Haro) in the limits with the Sierra Cantabria y Obarenes do not have conglomerates, due to their presence under the thrust sheet.

2. FACIES ASSOCIATIONS

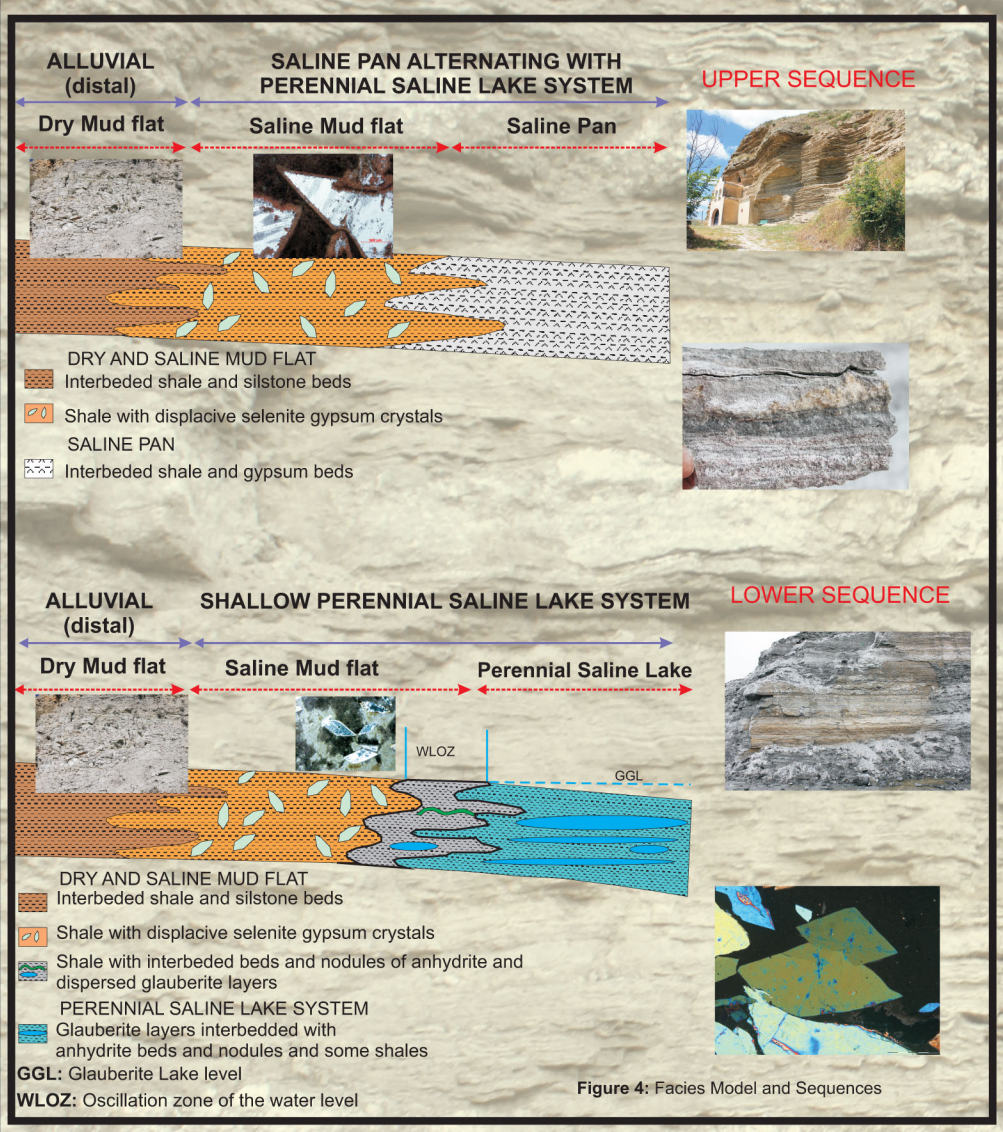

Figure 4: Facies Model and Sequences

The analyses of the facies associations reveals two different sequence of deposits. Both sequences have similar proximal environments, with alluvial fan facies and fluvial and mudflat facies. The sequences differ in the deposits of distal parts of the basin (Fig. 4):

The lower sequence is composed of saline Mud Flat deposits with displacive gysum crystals. This deposits change towards the center of the basin into interbedded shales with anhydrite and glauberite beds. the glauberite beds become thicker and wider as we move into more distal areas. This facies association represents a Perennial Saline Lake.

The Upper sequence doesn´t have any glauberite or primary anhydrite beds. Instead, the deposits of the distal parts of the system are composed of interbedded shales and gypsum layers. It has been interpreted as a Saline Pan environment with cycles of flooding alternating with dessication periods.

3. CORRELATION LINES

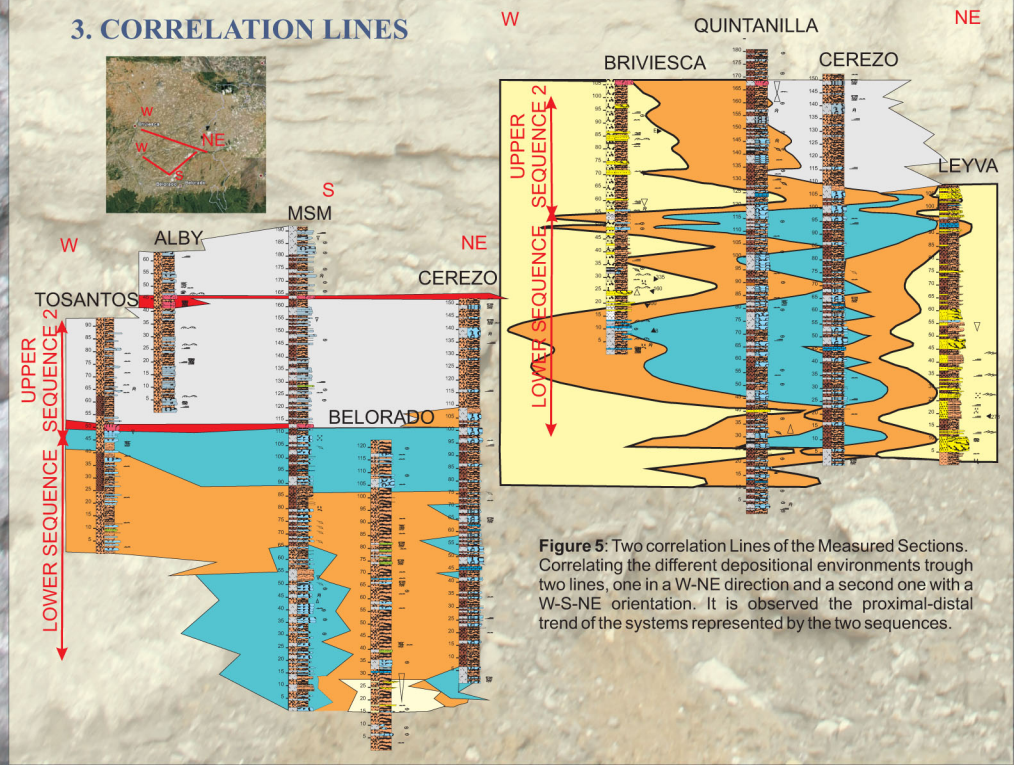

Figure 5: Two correlation Lines of the Measured Sections. Correlating the different depositional environments trough two lines, one in a W-NE direction and a second one with a W-S-NE orientation. It is observed the proximal-distal trend of the systems represented by the two sequences.

4. PHOTOMOSAIC OF THE FLUVIAL DEPOSITS

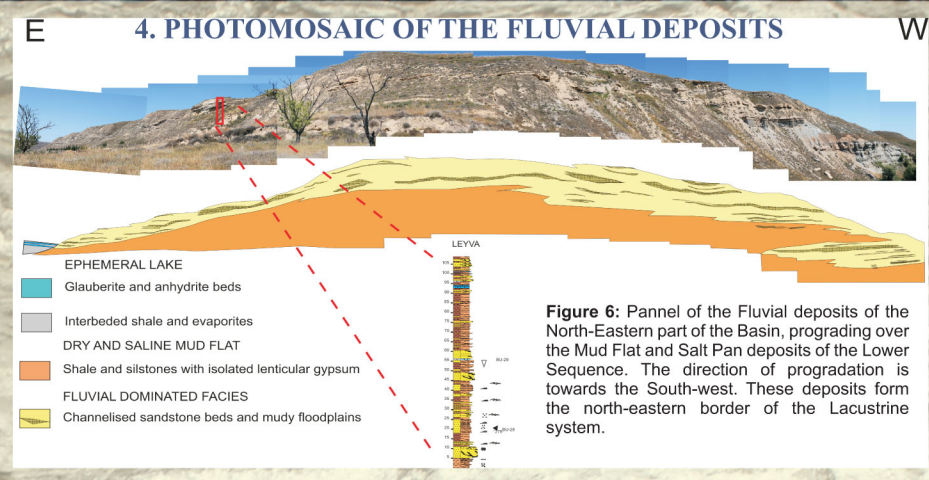

Figure 6: Pannel of the Fluvial deposits of the North-Eastern part of the Basin, prograding over the Mud Flat and Salt Pan deposits of the Lower Sequence. The direction of progradation is towards the South-west. These deposits form the north-eastern border of the Lacustrine system.

5. ISOTOPE ANALYSIS

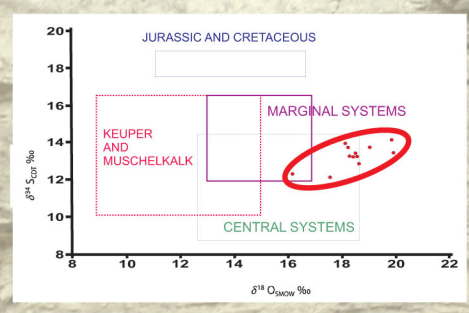

Figure 7: for δ18O and δ34S values for gysum units of the Bureba area (Modified from Orti, 2010).

Twelve gypsum samples of different lithofacies have been analysed for Sulphur and Oxigen stable isotopes (Fig.7). Mean value for δ18O is 18.61‰ (V-SMOW) and δ34S mean value is 13.25‰ (CDT). These values fit very well in the field of values that correspond to Central Systems of the Tertiary Ebro Basin presented by Orti (2010). These Central Systems depocenters appear more or less coincident with the central axis of the Ebro Basin. The depocenter of these lacustrine systems were moving towards the northwest as they were younger. These saline lacustrine systems are, among others, Talavera, Falces, Lerin, Monteagudo and Zaragoza gypsum. It means that our lacustrine system, close to the western border of the Ebro Basin, was the younger one of these evaporitic systems.

6. DEPOSITIONAL ENVIRONMENT

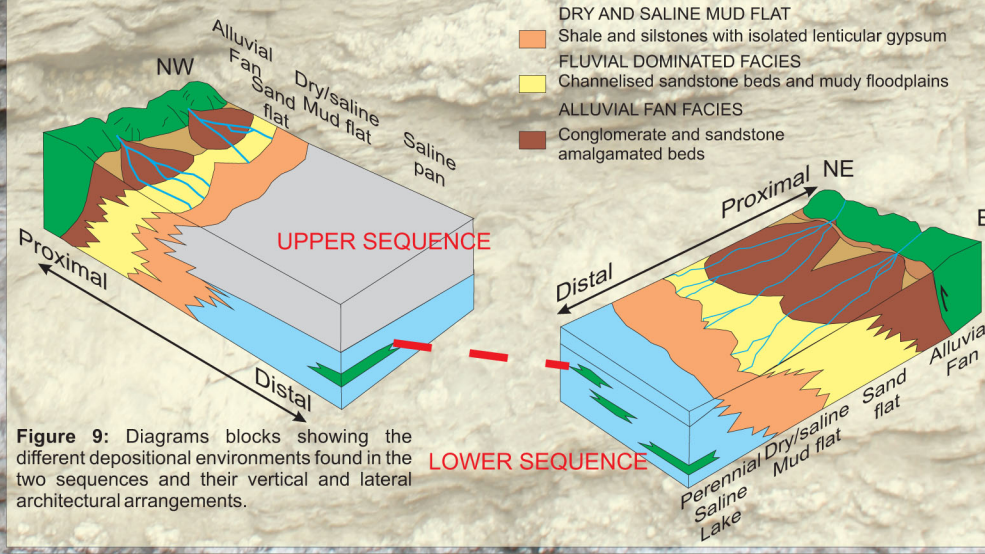

Figure 9: Diagrams blocks showing the different depositional environments found in the two sequences and their vertical and lateral architectural arrangements.

CONCLUSIONS

Based on the analysis of facies and facies associations, the mineralogy, isotope analyses and the establishment of correlations, we can conclude that:

* The Bureba area was a continental endorheic basin during Tertiary times. This basin was isolated from the rest of the Ebro Basin, and was feed by alluvial fan systems from the northern, western and southern borders of the basin.
* The alluvial fan facies changed towards the center of the basin into evaporate lacustrine systems. The chemistry of the brine was dominated by SO 4=, Ca 2+ and Na +. The source of this cations and anions were the dissolution of the nearby outcrops of Mesozoic evaporitic rocks.
* In the central area of the basin, two different evaporite systems have been identified:

The lower one, approximately 75 m. thick, formed by glauberite, anhydrite and shales that represents a perennial lake, rich in SO 4=, Ca 2+ and Na.

The upper system, 150 m thick, is a Saline Pan environment with dominant SO4=, Ca 2+, with gypsum as dominant mineralogy.

* The isotope analysis confirms that this system is similar to older evaporate lacustrine central systems found toward the south-eastern part of the Ebro Basin.

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