BETWEEN TIDES, WINDS AND RIVERS: DECIPHERING CHALLENGING SANDSTONE BODIES IN A MULTIFACETED COASTAL SYSTEM. LATE JURASSIC-EARLY CRETACEOUS, SOUTH IBERIAN BASIN, SE SPAIN

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The Upper Jurassic-Lower Cretaceous mixed carbonate-siliciclastic deposits of the South Iberian Basin (the Villar del Arzobispo and Aldea de Cortes Fms, Valencia and Teruel provinces, SE Spain, Figure 1A) constitute a regressive sequence, which can be subdivided in three main parts: 1) The lower part is composed of alternating marine carbonates (oolitic, peloidal and bioclastic), marl and sandstone deposited in the inner part of a mixed carbonate-siliciclastic marine platform (Mas *et al*., 1984; 2004); 2) The middle and upper parts of the sequence consist of an alternation of reddish siliciclastic mudstone, sandstone bodies, marl and minor conglomerates and marine bioclastic limestone, which have been interpreted as deposited, in most part of the South Iberian Basin, in a tidal flat surrounded by a coastal alluvial plain (Mas *et al*., 1981; 1984; 2004) and, to the northwestern Riodeva area of the basin (Figure 1A) in a fluvial system with some marine incursions (Luque *et al*., 2005). In these tidal and fluvial contexts sandstone bodies of the middle and upper part of the sequence are interpreted as deposited in tidal channels and in tidal bars developed in a tidal flat (Mas *et al*., 1981; 1984) or as fluvial channels (Luque *et al*., 2005), respectively. In this study we analyze the sandstone bodies of the middle and upper siliciclastic parts of the Upper Jurassic-Lower Cretaceous sequence in several outcrops along the South Iberian Basin (Figure 1A), and propose that many of the sandstone bodies have however an eolian origin, and were deposited in a tide-influenced eolian and coastal plain system.

Both channelized bodies and non-channelized sandstone bodies have been distinguished in the studied deposits. Channelized sandstone bodies are arranged in meter thick bodies (1-2 m), exhibit concave and erosive bases, limited lateral extension and may display inclined heterolithic stratification (Figure 1B). Towards the eastern sector of the basin, they may contain abundant bioclasts (ostreids, other bivalves and gastropods) at the base, which gradually decrease upwards. Channelized sandstone bodies are interbedded with reddish siliciclastic mudstone, which displays edaphic features, or with grey marl that may include alternations of sandstone displaying flaser, wavy and/or lenticular bedding and minor decimeter-scale bioclastic and sandy limestone beds, which contain abundant fragments of marine fauna (ostreids, gastropods, serpulids, benthic forams, echinoderms) and scarce oolites. These features suggest that channelized sandstone bodies were deposited in tidal channels developed in a tide-influenced coastal plain.

In addition, other channelized bodies composed of clast-supported conglomerate are occasionally observed interbedded with reddish siliciclastic mudstone. They are decimeter to meter thick (0.8-1.5 m), massive or cross-bedded and show concave and erosive bases, flat tops and short lateral continuity (up to 10 m). They are composed of micritic carbonate and scarce quartzite sub-angular to sub-rounded clasts (0.2-5 cm in diameter) within a fine to medium-grained sandy matrix. Scarce vertebrate remains have also been observed. These features suggest that channelized conglomerate bodies were deposited as ephemeral channels coming from the mainland and formed during episodic and intense flows.

Nevertheless, the most abundant sandstone bodies are non-channelized. Non-channelized sandstone bodies may be up to 10 m of thickness, as in the Riodeva area, show flat or slightly bases, flat tops and large lateral continuity (from 100m to, at least, 300 meters) (Figure 1B-H). They are

interbedded with reddish siliciclastic mudstone, displaying common edaphic features such as carbonate nodules and greenish mottling and occasionally, are interbedded with marl. They are composed of fine-medium to medium-grained sandstone, well- to very well-sorted, and display large-scale cross-bedding. Towards the lower part of the sandstone bodies (Figure 1F), cross-bedded sets are commonly not very thick (less than 60 cm and occasionally up to 1m) and display high angle (up to 35º, Figure 1F) tangential foresets, short lateral extension and abundant reactivation surfaces. Oblique erosion surfaces are also observed separating sets of cross-strata giving rise to wedge-shaped sets (Figure 1G). Locally, it is observed that the bottomsets and the lower part of the foresets may be draped by abundant peat remains (Figure 1H). Upwards cross-bedded sets commonly become thicker (up to 2.20m), displaying low angle foresets (less than 15º; Figure 1C, D), large lateral continuous bottomsets (Figure 1C, D) and reactivation surfaces. The bottomsets and, occasionally, the lower part of the foresets of low angle sets may be draped by thin layers of plant remains and mica flakes (Figure 1E). Locally, current and wave ripples, draped by plant remains and mica flakes, are also observed at the bottomsets. Sub-round to angular muddy soft pebbles (0.2-3cm) are present in some foresets.

Non-channelized sandstone bodies show several sedimentary structures (reactivation surfaces, current and wave ripples at the bottomsets, and mica flakes and plant remains draping the bottomsets and occasionally the lower part of the foresets), which are commonly interpreted as tidal in origin (e.g. Nio and Yang, 1991; Potén and Plick-Björklund, 2009; Martinius and Van den Berg, 2011). In fact, these sandstone bodies have been previously interpreted as subtidal bars (Mas 1981; Mas *et al*., 2004). If they were deposited as subtidal bars it would be expected that they were laterally and vertically related with facies containing marine fauna and displaying typical tidal structures, such as flaser, wavy and lenticular bedding, especially if we consider that non-channelized sandstone bodies are thicker and laterally more continuous than tidal channel deposits described above. However, non-channelized sandstone bodies are interbedded with reddish siliciclastic mudstone with common edaphic features, do not contain any marine fauna and show few evidences of tidal or marine influence. Therefore, a tidal origin for the cross-bedded and thick sandstone bodies should be questioned. Interpretation of non-channelized sandstone bodies as fluvial deposits (Luque *et al*., 2005) can be also be discarded as none of the features described above are characteristics of fluvial channel deposits.

On the contrary, all features of the non-channelized sandstone, such as large lateral continuity, thick sets, fine-medium to medium-grain size, good to very good grain-sorting, low angle foresets, high-angle tangential foresets, reactivation surfaces, wedge-shaped sets and even muddy soft pebbles within the sandy foresets, have been described by many authors as common features of eolian dunes, such as in the mid-Cretaceous coastal erg-system deposits of the Iberian Range (Rodríguez-López *et al*., 2008) and in other modern and ancient examples (e.g. Clemmensen *et al*, 2001; Mountney, 2006 and references therein). Moreover, the presence of current and wave ripples at the bottomsets and the presence of mica flakes and plant remains in the bottomsets and in the lower part of the foresets is a common feature in wet eolian interdunes, which develop as the result of a rapid rise in the water-table due to occasional fluvial inundations, ephemeral flash flooding from rainfall events or in coastal systems by storms, spring tides or periods of low air pressure (e.g. Langford and Chan, 1989; Mountney, 2006; Rodríguez-López *et al*., 2008 and references therein).

All these features suggest that the Upper Jurassic-Lower Cretaceous siliciclastic deposits of the South Iberian Basin were formed in a tide-influenced eolian and coastal plain system with deposition of intermittent alluvial sediments. Similar examples of marine-eolian interactions, in which eolian dunes prograde into the sea and are reworked by tides, have been reported in the mid-Cretaceous coastal erg-system of the Iberian Range and in modern arid regions by Rodríguez-López *et al*. (2012), although they also may occur in humid regions as it is currently observed in northern Brazil coast next to Santo Amaro do Maranhão town (Figure 1I).

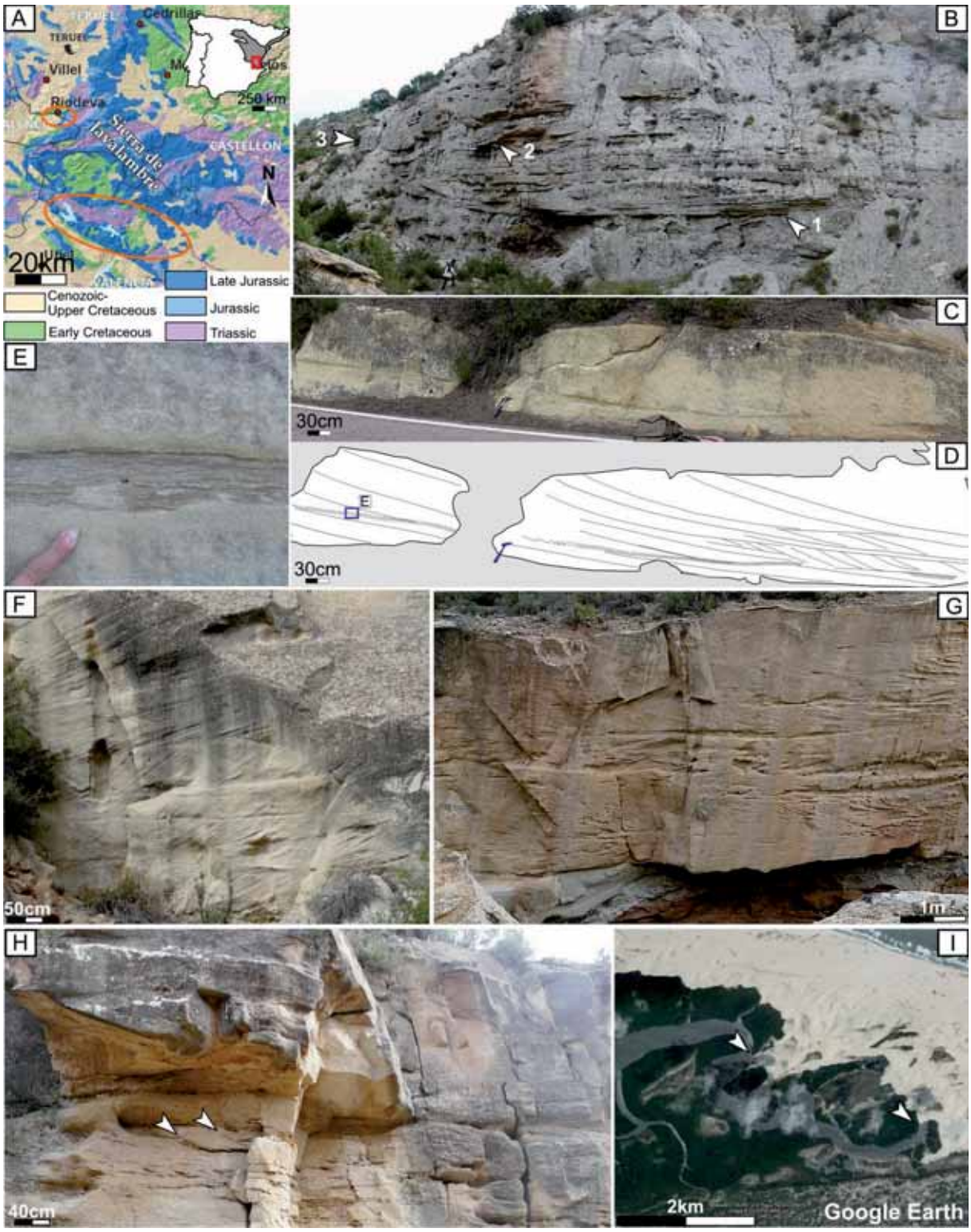

Figure 1. A) Location of the studied areas. B) Channelized bodies interbedded with marls (1, 2), displaying inclined heterolithic stratification. Non-channelized sandstone body (3) with flat base and top and large lateral continuity. C,D) Non-channelized sandstone body. Note the low angle foresets and the large laterally continuous bottomset of the thickest set, and the rippled sandstone containing mica and plant remains (E). F) Large-scale crossbedding in non-channelized sandstone. Note the upwards increment on set thickness. G) Non-channelized and large-scale cross-bedded sandstone interbedded with reddish siliciclastic mudstone. H) Foresets and bottomsets draped by peat remains (arrows) in non-channelized sandstone bodies. I) Google Earth image from northern Brazil coast in which it is possible to observed eolian dunes approaching tidal channels (arrows).

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