Ramp calcarenite sheet depositional system as a recorder of sea-level fluctuations (Late Albian, Alsasua, Spain)

El sistema deposicional de Rampa calcarenítica del Albiense Superior de Alsasua como registrador fluctuaciones del nivel del mar

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ABSTRACT

The Albian Aitziber calcarenites (Alsasua, Navarra) are analysed on the basis of their overall geometry, types of limiting boundaries, internal composition, facies, sedimentary structures and paleogeographical context. An «in situ» origin in shallow-water is inferred. The base of the calcarenite sheet represents an abrupt shallowing relative to the underlying basin. The top of the calcarenite records a drowning, hardground and a hiatus between the upper Albian and the upper Cretaceous. Sea level fluctuations related to a local tectonic origin were responsible for the calcarenite inception and demise.

Key words: *Calcarenites, hardground, sea-level changes, hiatus, Albian, north Spain*

RESUMEN

Se han analizado las calcarenitas albienses de Aitziber (Alsasua, Navarra) desde la perspectiva de su geometría global, tipos de límites, composición interna, facies, estructuras sedimentarias y contexto paleogeográfico. Se ha deducido un origen en aguas someras y esencialmente «in situ». La base de la unidad calcarenítica representa un evento de brusca somerización de la cuenca infrayacente. El techo de las calcarenitas registra un hundimiento con formación de fondo litificado y marca un hiato entre el Albiense superior y el Cretácico superior. Las variaciones relativas del nivel del mar causadas por tectónica local explicarían la instauración y la terminación de las calcarenitas.

Palabras clave: *Calcarenitas, hardground, cambios del nivel del mar, hiato, Albiense, norte de España*

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Introduction

The origin and significance of calcarenite lithosomes are subjects of ongoing research and controversy (e.g. Tucker and Wright, 1990). Calcarenite bodies can generate «in situ» on shallow-water carbonate environments, such as platforms and ramps (e.g. Burchette and Wright, 1992), or can be found resedimented in slope and basin margin settings (e.g. Scholle *et al.*, 1983). The recognition of shallow versus deeper-water calcarenites relies on the analysis of overall geometry of the lithosome, types of limiting boundaries, internal composition, facies, sedimentary structures and paleogeographical context. In this contribution we deal with a calcarenite sheet-type body, the Aitziber calcarenites, gathering evidence that points out the neritic affinity of this unit.

Geological setting

The Aitziber calcarenites crop out in central northern Spain, in the vicinity of the locality of Alsasua, at the NW end of the Navarra province in the border between Navarra and Guipúzcoa (Fig. 1). The toponymic Aitziber comes from the Aitziber hermitage, a small chapel located within the Urdiain syncline. The calcarenites occur to the north of the Bilbao fault line and form an elongated NW-SE trending band. Stratigraphically below the calcarenites a unit of micritic limestones crops out on both flanks of the Otzaurte syncline. These limestones belong to the Eguino unit (Fig. 1, Reitner, 1982, 1987; Gómez-Alday and Fernández-Mendiola, 1994; Matilla Sanz and Fernández-Mendiola, 1995; López-Horgue *et al.*, 1996). The Aitziber calcarenites crop out at the northern limb of the Otzaurte syncline. The syncline nucleus runs from Otzaurte to the area north of Alsasua and forms a depression traversed along by the Bilbao fault line. Tectonic dips of the calcarenites average 70 degrees. Two outcrop segments are diferentiated, the Sorozarreta ridge on the northwest side and the Urdiain and Iturmendi synclines to the southeast side (Fig. 1).

The structure of the Otzaurte syncline is well depicted by the presence of rigid limestone lenses on both flanks (Feuillée, 1967). The Aitziber calcarenites were interpreted as submarine-fan deposits by Reitner (1987). He identified them as «Crinoidenkalk» ocurring around the Etxegarate Pass and dated the unit as Vraconian (late Albian), based on the presence of *Rotalipora appenninica*, (Renz) *Rotalipora ticinensis (*Gandolfi*)* and *Planomalina buxtorfi* (Gandolfi) in the

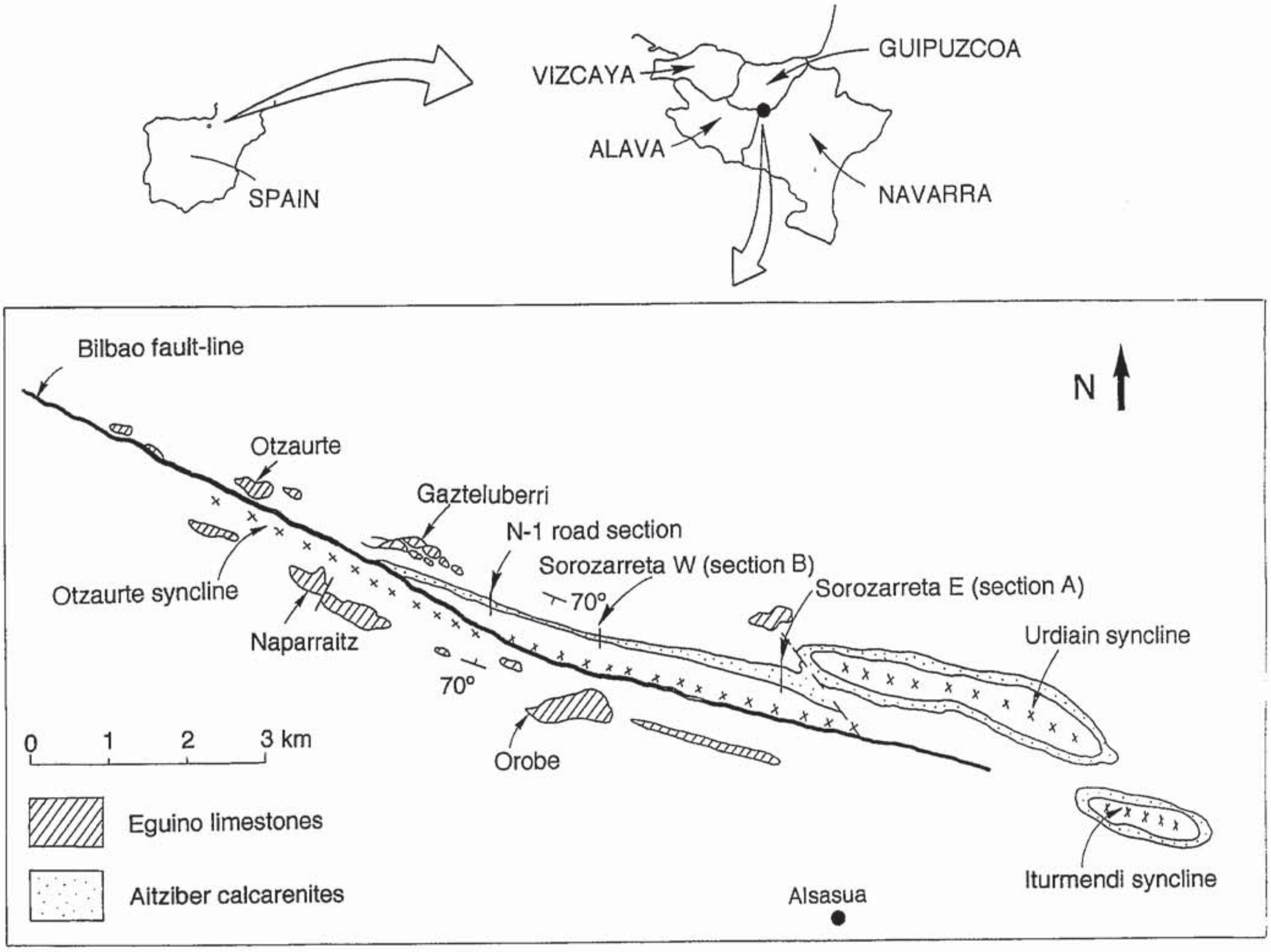

Fig. 1.- Geological setting of the study area. The Aitziber calcarenites crop out in northwest Navarra (north Spain) at the northern flank of the Otzaurte syncline. Towards the southeast the calcarenites are folded in two small synclines: Urdiain and Iturmendi.

Fig. 1.- Contexto geológico del área de estudio. Las calcarenitas de Aitziber afloran en el Noroeste de Navarra (Norte de España) en el flanco norte del sinclinal de Otzaurte. Hacia el Sureste las calcarenitas están plegadas en dos pequeñas sinclinales: Urdiain e Iturmendi.

calcarenites. Our own observations support this age attribution. However, we differ in the interpretation of the calcarenite paleoenvironmental setting. For us, various lines of evidence pointed out below suggest a shallow-water origin of the calcarenites.

Aitziber calcarenites

The dimensions of the calcarenite lithosome are approximately 10 km along depositional strike (NW-SE) versus a kilometer wide belt along depositional dip. The thickness of the calcarenites averages 30 m. The overall shape of the calcarenite unit is a broad sheet. Two stratigraphic sections (A and B, in Fig. 2) have been analysed in order to look for lateral variations along depositional strike. Section A was logged in the eastern part of the Sorozarreta ridge in an abandoned quarry and Section B is located 2.3 km to the west of section A in the same Sorozarreta ridge at an active quarry (Figs. 1, 2). Physical continuity and stratigraphic analysis along the calcarenite ridge allow a good correlation for the top boundary of the calcarenite. The lower boundary of the calcarenites differs in character from one section to the other and lateral correlation is inferred.

Section A: In the stratigraphic log of figure 2, three principal units (1, 2 and 3) have been differentiated. A lower marly unit, containing carbonate diagenetic nodules and *Biticinella breggiensis* (Gandolfi) (Reitner, 1987). Based on regional data this unit belongs to the late Albian (s.l.), and was deposited in a basinal setting. Unit 2 is made up of limestones and stands on unit 1. The limiting boundary between both units is sharp. Three subunits or divisions of unit 2 consist respectively of: 2-1, nodular limestones; 2-2, medium to coarse-grained calcarenites and 2-3, micritic limestones.

Subunit 2-1 is 8 m thick and contains alternating argillaceous marls and wavy calcarenites with glauconite, plant fragments (coal), ammonites, planktonic foraminifera, abundant sponge spicules and echinoderm fragments. These thinly bedded couplets of structureless bioclastic packstone and bioturbated marly limestone are indicative of two contrasting energy regimes. Episodic flows transported the skeletal fragments whereas marls accumulated from low energy suspension deposition. The presence of very common bioturbation indicates an oxygen-rich seafloor.

Subunit 2-2 is 28 m thick and has a sharp erosive lower boundary. Pure calcarenites overlie wavy limestones of the previous subunit. Depositional features such as channels are frequent. They are two to three meters-thick and are filled by lateral accretion foreset bars. Channel fills are depositional strike parallel and channel axis

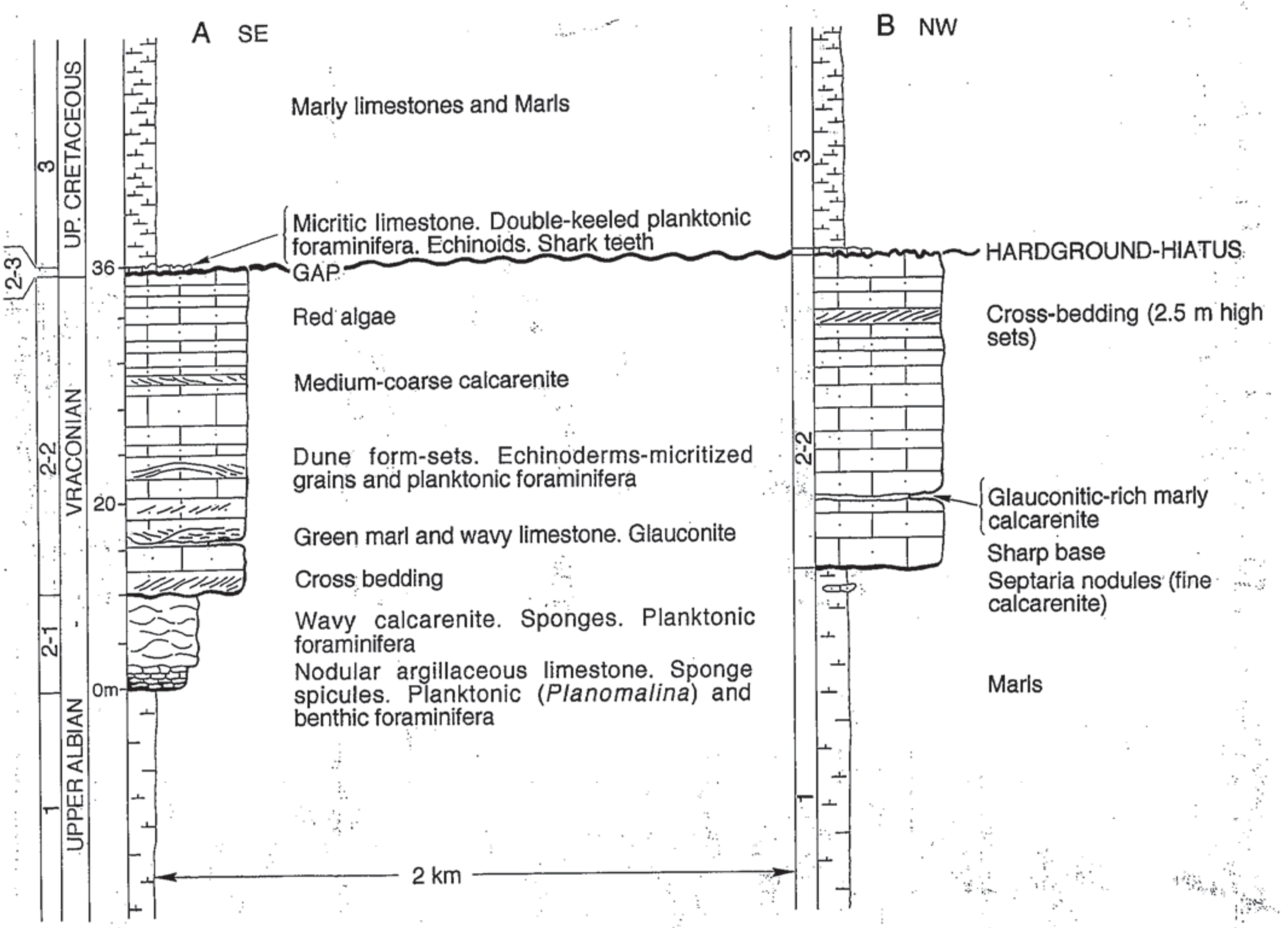

Fig. 2.- Stratigraphic logs A (Sorozarreta E) and B (Sorozarreta W). See location in figure 1. Note the sharp bounding surfaces at the bottom and top of the Aitziber calcarenites (unit 2-1 + 2-2). The surfaces respectively reflect a sudden relative sea-level fall at the bottom of unit 2, and a sharp relative sea-level rise on top of the calcarenites.

Fig. 2.- Columnas estratigráficas A (Sorozarreta Este) y B (Sorozarreta Oeste). Ver su ubicación en la figura 1. Observense las bruscas superficies limitantes a la base y el techo de las calcarenitas de Aitziber (Unidades 2-1+2-2). La superficie basal refleja una brusca caída del nivel del mar relativo a la base de la unidad 2 y la superficie de techo registra un brusco ascenso del nivel del mar relativo.

are approximately parallel to slightly oblique with respect to depositional dip (N55E). The cross-beds show bidirectionality, a 2m thick megaset accretes laterally towards the east, whereas in section B an analog 3m thick set progrades westwards, suggesting tidally influenced deposition (e.g. Ramsay, 1987). The calcarenites of division 2-2, generally lack bioturbation, contain abundant glauconite, micritic intraclasts, echinoderm fragments with sintaxial cements, red algae, and common styliolitic contacts favoured by the absence of early submarine cements. The fragmented crinoid and echinoid allochems were dissarticulated and transported by currents.

The greenish mineral glauconite is common in shallow marine areas where the rate of sedimentation is slow. It is a poorly cristallized mica rich in potassium and iron. The association with decaying organic matter and a high concentration of iron in interstitial waters (at conditions intermediate between reduction of iron oxide and precipitation of sulfide) are necessary conditions of growth (Seibold and Berger, 1982). Once formed in a slow net sediment accumulation setting, glauconite particles can be redeposited in energetic, well-oxigenated waters (Lewis and McConchie, 1994).

Locally we have recognized hummocky cross stratification. Although there is great debate at the moment concerning the origin of hummocky cross stratification, there is agreement that oscillatory currents, due to storm surface gravity waves, play a Key role in its formation (Allen, 1985; Brenchley, 1985; Dott and Bourgeois, 1982; Duke, 1985; Swift and Nummedal, 1987).The top of division 2-2 is a bored hardground surface overlain by subunit 2-3.

The vertical depositional evolution from division 2-1 to 2-2 suggests a shallowing up trend. Medium to distal ramp facies deposited intermitently below and above wave base level are succeded by proximal ramp shoal-type facies deposited above wave-base level. On the other hand, the evolution from division 2-2 to 2-3 represents a sharp deepening of facies.

Subunit 2-3 is 0.5 m thick and consists of a micritic limestone full of planktonic foraminifera, very abundant glauconite, echinoderms, shark teeth and brachiopods. The planktonic foraminifera are double-keeled forms which correspond to upper Cretaceous forms. This layer could be a condensed interval perhaps encompassing mixed forms. The top of the micritic layer contain phosphatic cauliflower nodules and is a ferruginous irregular surface. Unit 3 consists of monotonous marly limestones and marls, displaying upper Cretaceous planktonic foraminifera. In the (Ramirez, *et* *al.*, 1987) geological map of Spain (scale 1:50.000), Alsasua sheet (number 114), Albian recristalized calcarenites (number 17), corresponding to the Aitziber calcarenites, are interpreted as biostromes deposited in high energy settings in the platform. The overlying facies number 18, consists of Turonian marls. So that a local sedimentary hiatus is deduced. The Cenomanian and probably the lower Turonian would be absent.

Section B: Essentially consists of the same three basic units logged in section A (Fig. 2). However the basal part of unit 2 is rather different. The main difference is that in section B, the subunit 2-1 is absent. Instead, subunit 2-2 consisting of glauconitic shallow-water calcarenites overlies abruptly unit 1. The latter consists of deeper-water marls which crop out in the N-1 road section (Fig.1). There, they contain ammonites and sandstone/micritic lithoclasts in slumped layers (Fig. 1).These events record instability conditions in slope settings. In the same N-1 road section the basal part of division 2-2 shows amalgamated graded beds (30-40 cm thick), consisting of packstone layers above planar or ondulatory basal scour surfaces. These scours were likely generated by violent storms or hurricanes. Each graded bed shows a sharp and planar basal contact but locally there are shallow scours. The basal lag consists of (4-5 cm thick) skeletal-intraclast grainstone grading upwards to medium skeletal calcarenite. The upward decrease in grain-size is indicative of a reduction of depositional rate or waning of current energy.

At meter 6, an intercalation glauconitic rich marly calcarenite can be correlated with a coeval green marl and wavy limestone layer located in section A (Fig. 2) also very rich in glauconite. This episode might represent a short pulse of deepening and condensation in the depositional evolution of the calcarenites. The top of the division 2-2 records the drowning event with the hardgroung development and associated hiatus.

Conclusions

The overall size, geometry and internal composition of the Aitziber calcarenites point to an «in situ» origin in a shallow-water carbonate environment of ramp type, rather than a submarine fan type deposit as previously considered by Reitner (1987). The calcarenites reflect deposition in a high energy environment whithin wave activity levels. Bedding thickness, degree of amalgamation, grain size and sorting reflect that the Aitziber calcarenites form a regressive sequence.

The sedimentary evolution from division 2-1 to 2-2 records deposition from below mean wave-base to the tidal-storm (wave) dominated crinoid-echinoid shoal. The Aitziber calcarenite sequence is storm-wave dominated with hummocky cross-stratification (HCS) and migratory megaripple cross-bedding. Features indicative of episodic high energy events are: the presence of basal scours, the reworking of wackestone into intraclasts, the presence of hummocky cross stratification, local decrease in grain-size upward in a single bed. Similar stacked storm event deposits have been described and interpreted by Goldring and Bridges (1973) or Faulkner (1988). Additionally, the scour and fill is indicative of localized very intense currents.

The calcarenite inception marks a sudden shallowing of the underlying basin (e.g. section B, Fig. 2), reflecting a relative sea-level fall probably at the dispar Zone (Vraconian) or a less sharp shallowing episode (as in the case of section A and in the Urdiain syncline preliminary observations). The demise of the calcarenite is marked by a hardground surface, indicating by a drowning event caused by a relative sea-level rise. Ramps are low productive carbonate systems and may therefore drown readily. Rapid base level rises cause drowning and this is the reason why many ramps are thin and less productive than rimmed carbonate platforms (Burchette and Wright, 1992).

The hiatus has been recognized along the Otzaurte syncline in a relatively small sector. Elsewhere, in the surrounding areas of the study area, the logs record Cenomanian and Turonian successions overlying the Albian.The hiatus inferred at the discontinuity surface in the Otzaurte area is indeed significant and probably reflects the synsedimentary activity of the Bilbao fault line. This synsedimentary faulting is related to plate displacement and interaction between Iberia and Europe reflected in the sedimentary history of the north iberian margin (García-Mondéjar *et al.*, 1996).

Acknowledgements

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