Contrasting styles of paleokarst infill in a block-faulted carbonate ramp (Lower Albian, Trucios, N Spain)

Diferentes tipos de relleno de paleokarst en una rampa carbonatada afectada por fallamiento distensivo

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RESUMEN

En el Complejo urgoniano de Trucios (Vizcaya) se caracteriza una superficie de paleokarst que presenta rellenos sedimentarios diferentes en función del dominio tectosedimentario. Tras una fase de paleokarstificación de la rampa carbonatada se produce la formación de un sistema de horst-graben. La invasión marina subsiguiente rellena primero las cavidades kársticas en el graben con areniscas silíceas de estuario. Cuando el nivel del mar alcanza el techo del horst, se comienza a rellenar el paleokarst en su techo, pero las facies de relleno son calizas subtidales en tanto que por el graben continua canalizándose el grueso de sedimentos siliciclásticos del sistema deltaico-mareal de procedencia meridional.

Key words: *Paleokarsts infill, Tilted blocks, Carbonate ramp, Lower Albian.*

Geogaceta, 11 (1992), 42-44.
ISSN: 0213683X

Introduction

The Urgonian Complex of the Basque-Cantabrian region is an Aptian-Albian heterogeneous package of siliciclastic and carbonate facies, which range from fluviatile to deep marine. This work concerns the sedimentological features of a shallow marine unit within the Urgonian: the subtidal Peñalba calcarenites.

This unit outcrops in the southern flank of the Bilbao Anticlinorium, to the west of Vizcaya province (fig. 1). It broadly constitutes a carbonate ramp, 16 km wide and 30-72 m thick. The ramp inception represents an expansive shallowing-upwards episode in the Lower Albian, with respect to the underlying and overlying facies of the area (Aranburu *et al.*, 1991 a). Original descriptions of the Peñalba calcarenites (Herrero, 1989) referred to an homogeneous tabular unit with a local paleokarst on top of it. However, no detailed documentation of this paleokarst from a sedimentological, stratigraphical and paleogreographical viewpoints has been done so far. Most of the arguments justifying the use of the term paleokarst rested upon the presence of cavities filled with ores (Pb-Zn) (Herrero, 1989). However, mineralized Mississippi-valley local settings in this area not the best sites for paleokarst diagnostic features to be found.

Working in a dynamic stratigraphical context, we revealed, analyzed and characterized seven new sedimentary discontinuities in the Peñalba calcarenites, and followed them from shallow ramp, with paleokarstic development at least in two sequences, to deep ramp, with submarine paleocanyon deelopment (Aranburu *et al.*, 1991 b). In this study we describe the general characteristics of the paleokarst on top of the Peñalba calcarenites, and the general tectosedimentary evolution which led to different styles of infilling, diagenesis and preservation. Block-faulting after a period of

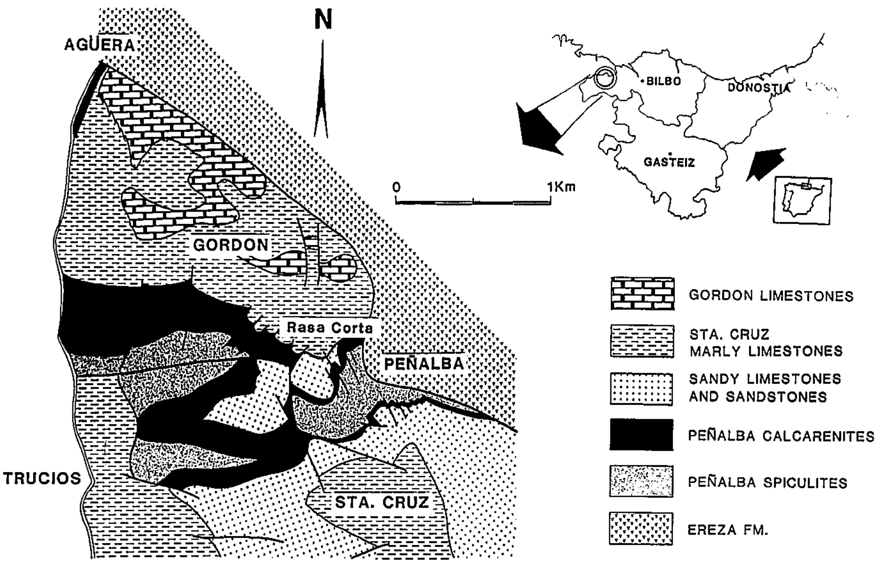

Fig. 1.—Location of the Agüera and Peñalba paleokarst on top of the Peñalba calcarenites.

Fig. 1.—Localización de los paleokarst de Agüera y Peñalba a techo de la unidad calcarenítica de Peñalba (en negro).

carbonate ramp emergence, led to the development of two different tecto-sedimentary domains: a) the Peñalba graben and 4 km to the west, b) the Agüera horst block. Both domains are separated by a normal synsedimentary fault.

Peñalba domain

The top of the Peñalba calcarenites show spectacular paleokarstic features in this area, concretely in the northern side of the Peñalba river at the Rasa Corta site. The paleokarstic cavities stand in the topmost 10 meters of the skeletal crinoidal grainstones. Two contrasting types of cavities are found: 1) meter-sized cavities placed on top of the calcarenites and filled with sandstones and 2) meter-sized cavities filled with ores, laterally adjacent to and below the first cavity types. The ores consist of sphalerite and galena and they appear in irregular cavities (Herrero, 1989). The origin of these type-2 cavities is still uncertain, although we favour a hydrothermal karst superimposed on previously leached calcarenites during a phase of subaerial exposure, based on geometrical petrological and sedimentological grounds. On the other hand, type-1 cavities formed by meteoric dissolution following the ramp emergence and were filled by marine sandstones in a estuarine environment.

Figure 2, represents and elongated type-1 cavity 3 m wide and 1 m high. The encassing limestones below and in the central area (protruding wall-rock arm) are crinoidal grainstones displaying cross-lamination. The infill facies are entirely siliciclastic, medium to fine-grained litharenites with, medium scale low-angle cross bedding. The contact between the siliceous sandstone and the wall-rock limestone is abrupt an irregular.

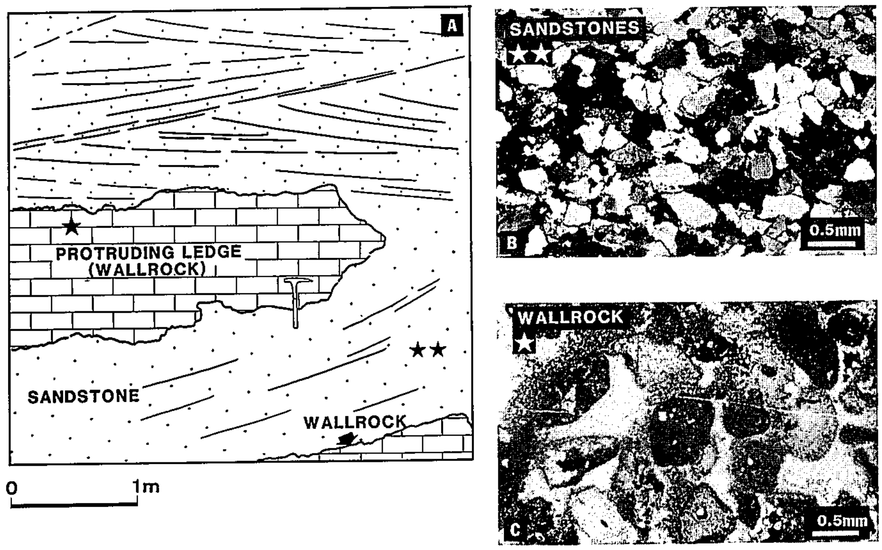

Fig. 2.—Sketch of a type-1 paleokarst cavity in the Peñalba area (Rasa Corta) (A). Note the irregular boundaries between the wallrock and the cross-bedded sandstones infilling the cavity B & C: Photomicrographs of wallrock and infill facies.

Fig. 2.—Esquema de la cavidad rellena de arenisca siliciclástica en el karst de Peñalba (Rasa Corta). Obsérvese la superficie irregular de la roca encajante (calcarenita de Peñalba) y las estratificaciones cruzadas de bajo ángulo que muestra la arenisca del relleno.

Agüera domain

In this domain there are also many paleokarstic cavities affecting at least the topmost 7 m of the Peñalba calcarenites, but contrastingly, neither sandstone facies nor ore deposits appear infilling the cavities. On the contrary, these cavities are filled with fine-grained shallow-marine carbonates. Figure 3 represents one of the paleokarstic cavities in this area. It is a concave-up cavity (1.25 m widex x 0.8 m. minimum high) with smooth to irregular boundary surface, that resembles the lower geometry of the karstic pipes described by Boughen and Walsh (1980). The wallrock facies resemble those found in the Peñalba domain, as they are peloidal/skeletal grainstones including crinoidal and micritized grains. The infilling deposits are predominantly carbonates, and include heterogeneous breccias, oncoidal micrites, detrital rudstones, and massive micrites recristalyzed to microsparites. The only siliciclastic deposits are very fine-grained lutites in millimetric layers. Figure 4 represents another example of small-scale paleokarstic structure. It is a photomicrograph sketch showing the wallrock skeletal-intraclastic calcarenites, which include a micropore (vug) filled with geopetal micritic limestone. An isopachous, early-calcite cement rims the cavity interior separating the dissolutional phase from the micritic cavity-filling phase.

Tectosedimentary evolution

Based on the contrasting types of paleokarst infill, mineralization distribution, regional tectonic framework and the coeval origin of paleokarst in both domains, we have established an evolutionary trend consisting of three stages (fig. 5).

1) *Karstification phase*

A submerged, healthy-producing carbonate ramp is affected by a relative sea-level drop of 10 m minimum. Subaerial exposure of the carbonate ramp followed in the proximal ramp setting, while the distal ramp kept on submerged. The exposure led to karstification processes in the meteoric environment. The relative sea-level fall ended a general relative lowering

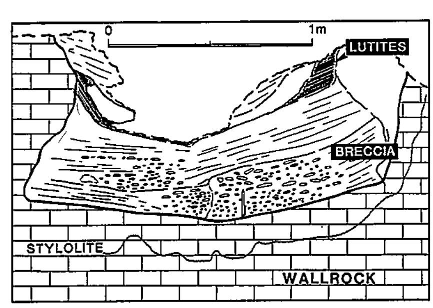

Fig. 3.—Sketch of a paleokarst cavity in the Agüera area with a multiepisodic laminated infill.

Fig. 3.—Esquema de la cavidad del paleokarst de Agüera, presentando un relleno multiepisódico gradado.

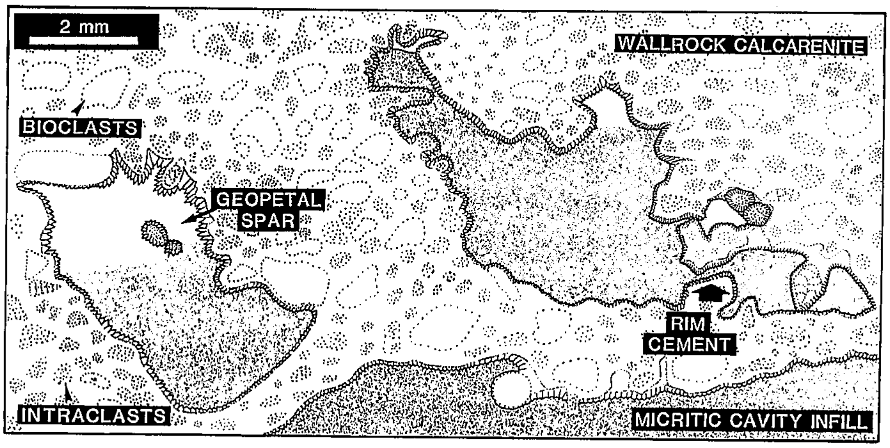

Fig. 4.—Photomicrograph sketch of a minor cavity of the paleokarst in the Agüera area: a) Wallrock-skeletal packstone; b) Cement rimming the dissolution cavity; c) Laminated geopetal infill facies.

Fig. 4.—Esquema a partir de microfotografía de una cavidad menor del paleokarst en la zona de Agüera. a) Caliza encajante (packstone). b) Cemento rim bordeando la porosidad creada por disolución. c) Relleno laminado y geopetal de la porosidad.

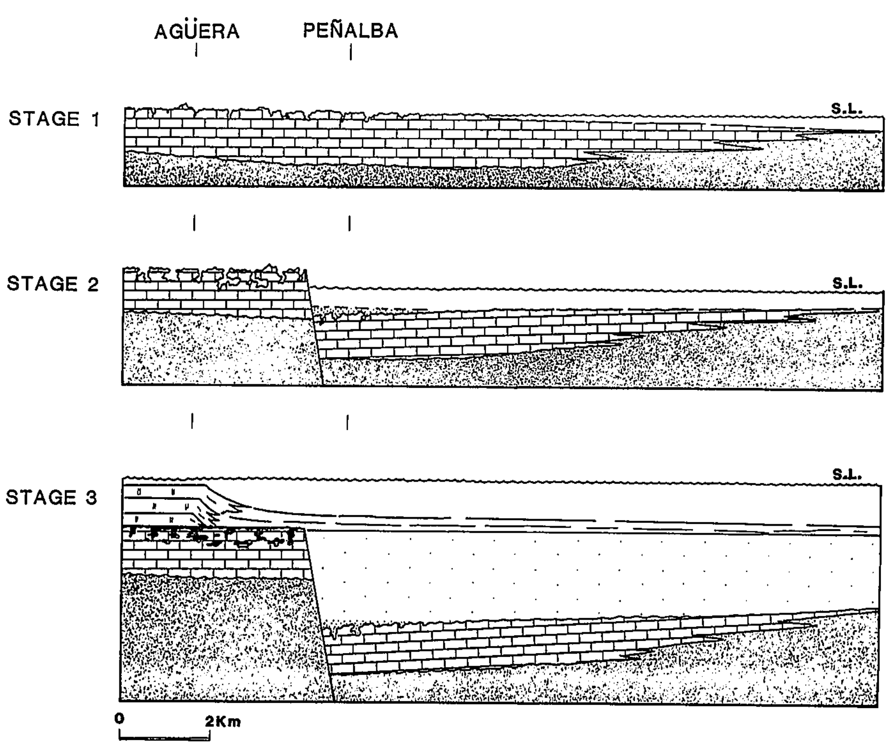

Fig. 5.—Tectosedimentary evolution of the uppermost part of the Peñalba calcarenite unit. Both areas share a common paleokarstification phase (stage 1), but synsedimentary faulting separates two domains (Peñalba and Agüera) of different subsidence (stage 2) and infill (stage 3).

Fig. 5.—Evolución tectosedimentaria de la parte superior de la unidad de calcarenitas de Peñalba. Fase común de paleokarst (estadio 1). Actuación de la falla sinsedimentaria (estadio 2) que separa los dominis de Agüera y Peñalba, con diferente subsidencia y relleno (estadio 3).

trend deduced from the shallowing upward sequence of the upper part of the Peñalba calcarenites.

2) *Block-faulting phase*

The emergent carbonate ramp is dissected by a NNE-SSW trending synsedimentary fault, which separates two differently subsiding domains: a) relatively reduced subsidence rates in the horst block (Agüera domain), and b) relatively accentuated rates in the graben block (Peñalba domain).

3) *Marine transgression*

In the graben sedimentation rates were significantly higher than in the horst. As the sea invaded the area, estuarine sandstones began to fill first the cavities in the whole trough. At the same time, in the horst block the limestones were still subjected to karstification processes prior to the definitive marine transgression. However, when finally the sea invaded the horst, the first deposits to be laid down in the cavities were in situ produced carbonates, in contrast with the siliciclastic infill of the paleokarst in the graben.

Ore genesis

The lead-zinc mineralization associated with the paleokarstic structures occurs only in the Peñalba domain, where the paleokarst cavities are filled with ores or sandstones. All the ore cavities are close to the above described synsedimentary fault. The relationship between ore location and paleogeographic domain strongly suggests that the mineralizing brines could have circulated along this fault, at least during their first emplacement phase perhaps during the period of accentuated tectonism that originated the tilted blocks. The ore entrapment would have occurred only in the down thrown block or graben block (hanging wall) and, if this hypothesis is correct, it would have taken place early in post Peñalba paleokarst time.

Acknowledgements

Funding for this work was provided by Project U.P.V.121.310.# 014/90 from the País Vasco University.

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Recibido el 1 de octubre de 1991
Aceptado el 25 de octubre de 1991