# Facies analysis and correlation in an Albian carbonate platform (Cuchía quarry, Cantabria, Spain)

***Análisis y correlación de facies en la plataforma carbonatada albiense de la cantera de Cuchía (Cantabria)***

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***ABSTRACT***

*We analyze sedimentary facies variations in an Albian shallow-marine carbonate platform succession of the western Basque-Cantabrian Basin. Two stratigraphic sections were logged in the Cuchía quarry. The facies show a great heterogeneity. They are mainly micrites with rudists, corals and Chondrodonta, and bioclastic calcarenites. A depositional model after facies associations and cycle analyses across a 1.5 km transect includes four palaeoenvironments: 1) inner lagoon Bacinella/gastropod and miliolid micrites, 2) outer lagoon with fine calcarenites (packstones with miliolids and orbitolinids, 3) platform margin and slope with coral boundstones and 4) tidal trough with calcarenites from migrating bars and channels making up large-scale cross-bedding and high-energy facies.*

***Key-words:*** *Albian, Basque-Cantabrian Basin, Cuchía quarry, carbonate platform, facies correlation.*

***RESUMEN***

*Se han estudiado las variaciones de facies sedimentarias en una sucesión albiense de calizas someras de plataforma carbonatada a partir del análisis de dos secciones estratigráficas en la cantera de Cuchía (parte occidental de la Cuenca Vasco-Cantábrica). Las facies estudiadas muestran un desarrollo muy heterogéneo. Están formadas por: 1) calizas micríticas de rudistas, corales y Chondrodonta, y 2) calcarenitas bioclásticas. Se ha establecido un modelo deposicional de Este a Oeste en una distancia de 1,5 km con facies de: 1)* lagoon *interno restringido con micritas de Bacinella, gasterópodos nerineidos y miliólidos 2)* lagoon *abierto de calcarenitas finas de miliólidos y orbitolínidos, 3) facies de margen de plataforma constituidas por micritas de corales masivos y 4) facies de surco calcarenítico mareal, con estratificaciones cruzadas a escala métrica.*

***Palabras clave:*** *Albiense, Cuenca Vasco-Cantábrica, cantera Cuchía, plataforma carbonatada, correlación de facies.*

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## Introduction

During the Albian the Basque-Cantabrian Basin developed several shallow carbonate platforms. In the north Santander area the Reocín Fm. (Early Albian) and the Barcenaciones Fm. (Late Albian) are examples of these platforms. Associated to the platforms there are basinal troughs with neritic facies, including marls and marly limestones with ammonites and brachiopods.

In this work we present the results of facies analyses in the platform succession of the Cuchía quarry (Fig. 1).

We compare two sections 1.5 km apart. One is located in the eastern margin of the quarry, and the other in the western margin of the quarry, along the Ría de San Martín (Fig. 1).

## Geological setting

The study area, located in the northern part of the Spanish province of Cantabria (Fig. 1), belongs to the Basque-Cantabrian Basin. Deposition in the Albian took place in subtropical palaeolatitudes of 25-30°N, and the Albian was characterized by a warm palaeoclimate (Barron *et al.*, 1995).

The Cretaceous succession of the North Cantabrian Basin was studied in the last century by Mengaud (1920) and Ramírez del Pozo (1971) who published general stratigraphic surveys of the region. The Urgonian (Aptian-Albian) sections investigated by Rat (1959), Pascal (1985) and García-Mondéjar (1982). The Albian sediments of the Cuchía quarry belong to the third and fourth biosedimentary systems of Pascal (1985). However, detailed facies studies on these units are still rare so that their sedimentology is poorly known.

## Facies analysis

The logging of two vertical sections and the study of thin sections has allowed the recognition of 14 sedimentary facies representative of shallow subtidal, deeper-water subtidal and deltaic.

Facies 1 is a micrite with rudists (requieniids and polyconitids), corals, and *Chondrodonta* sp., miliolids and gastropods.

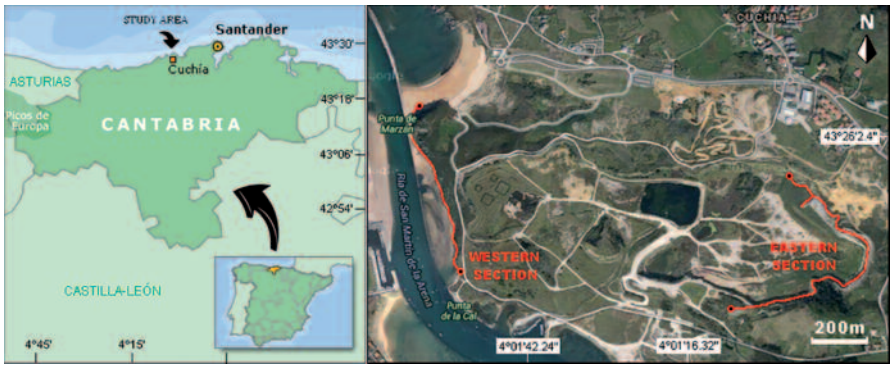



**Fig. 1.- Location map of the studied area in north Spain, north Cantabria province, Cuchía locality. Eastern and western sections are outlined in a landsat image.**

***Fig. 1.- Mapa de situación del área estudiada.***

It represents a shallow subtidal environment.

Facies 2 is a micritic limestone with abundant *Bacinella irregularis* masses, associated minor miliolids, ramose and massive corals and gastropods. A two-coloured micrite (grey and reddish with vuggy pores) is common. Facies 2 exclusively occurs in the eastern section and represents a restricted platform interior environment.

Facies 3 is a coral boundstone, composed of massive corals (up to 1 m in length) and is found only in the western section. It indicates an open marine shelf margin setting.

Facies 4 is a micritic limestone full of rudists, mainly requienids. Locally, however, monopleurid bouquets, caprinids and polyconitids form the biostromes, with accompanying components such as miliolids, gastropods and *Chondrodonta*. Facies 4 is more common in the eastern section. It represents reef environments in platform interior or margin settings.

Facies 5 is a micritic limestone full of *Chondrodonta* oyster-like bivalves. These organisms constitute a framework made up of tightly packed specimens in living position that reach up to 50 cm in length. They developed in the platform interior.

Facies 6 is a fine-grained packstone with miliolids, orbitolinids and ramose-massive corals. It is more abundant in the eastern section.

Facies 7 is made up of fine-medium grainstone, with orbitolinids, miliolids and corals. This facies occurs in the eastern section and corresponds to platform interior sediments winnowed by shallow-marine currents temporarily affecting the lagoonal areas. Both facies 6 and 7 show locally discontinuous thin marly interlayers (partings), often rich in orbitolinids.

Facies 8 consists of medium to coarse-grained calcarenite (rudstone) composed of echinoid fragments, crinoids, ostreids and minor miliolids and orbitolinids. The calcarenites display large-scale sets up to 2 m thick of cross-bedding. Palaeocurrents dominantly show a northward transport (N009ºE average). This facies occurs in the western section. The rudstones with unipolar cross-bedding suggest dune migration on a shallow-seafloor affected by tidal currents. Most of the units lay onto palaeokarst surfaces and disappear towards the east likely by lateral wedging.

Facies 9 is a nodular calcareous marl with gastropods, massive corals, brachiopods, orbitolinids and burrows. It is recognized on the eastern section and represents open marine conditions.

Facies 10 is a wavy nodular calcarenite, and facies 11 is a silty and sandy wavy/nodular calcarenite. Both facies present interlayered fine terrigenous mud, silt and/or sand. The calcarenites contain corals, gastropods, ostreids, echinoids, thin discontinuous layers of coal (1-2 cm thick) and local bioturbation is common. Facies 10 and 11 suggest slight deepening pulses relative to encasing strata.

Facies 12 and 13 are silty and sandy calcarenites and sandstones/siltstones respectively. They suggest abundant terrigenous input brought in from continental areas.

Facies 14 is composed of sandstones, siltstones and sandy calcarenites with ostreids. It is related to a shallow-marine coastal environment (deltaic) and belongs to the lower Cenomanian Bielva Fm.

## Stratigraphic correlation

Both sections (Fig. 2) are made up of limestones spanning from the early Albian to the late Albian (Pascal, 1985). They correspond to the Reocín and Barcenaciones Fms. The Lower Albian Reocín Fm. contains *Orbitolinopsis reticulata*, and *Orbitolina (Mesorbitolina)* gr. *texana-minuta*. The upper Albian Barcenaciones Fm. contains *Caprina choffati* and *Orbitolina (Mesorbitolina) subconcava*, *Neorbitolinopsis conulus* and *Orbitolina concava*. The Bielva sandstones and siltstones in the upper part of both sections are the best correlation horizon.

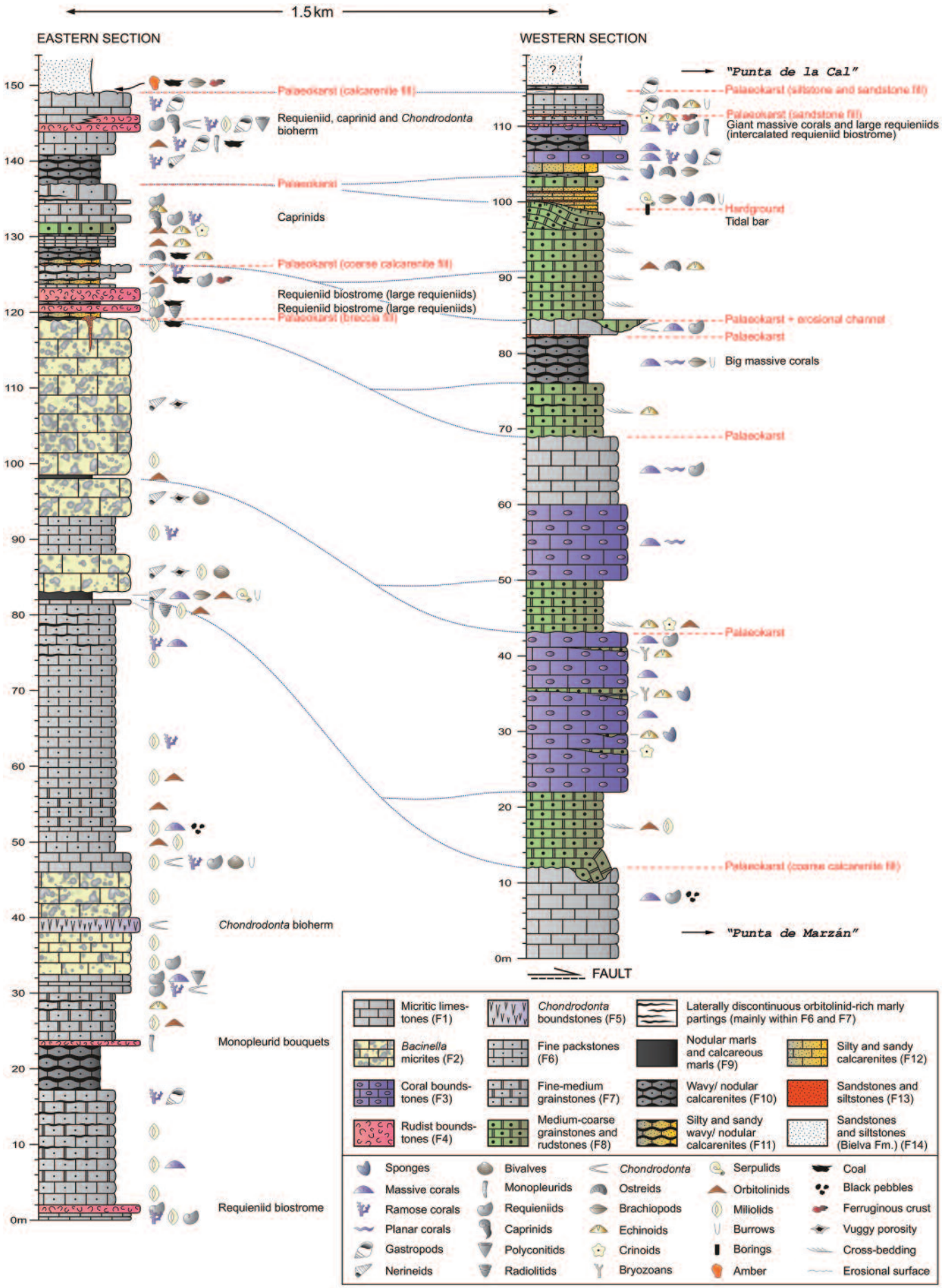
The western section contains abundant coral facies and coarse calcarenite/rudstone facies (blue and green colors respectively in Fig. 2). These facies are virtually absent in the eastern section where *Bacinella* micrites (yellow, in Fig. 2) and miliolid limestones are common throughout. Several palaeokarst and omission surfaces have been recognized, namely at metres 82, 98, 119, 126, 137 and 149 in the eastern section and at metres 12, 43, 69, 82, 84, 111 and 114 in the western section.

We have established correlation lines based on the sedimentary sequence and facies associations and using key-discontinuity surfaces (Fig. 2). The correlation suggests that subsidence rates were slightly higher in the western area, i.e., in a depositional downdip direction. A turnover point in the vertical succession is metre 119 of the eastern section. Below it, there are dominant pure limestones with *Bacinella irregularis* and miliolid, gastropod and orbitolinid facies. These facies end with a very important palaeokarst surface (metre 119). The succession above the palaeokarst surface contains mixed carbonate and siliciclastic facies. The palaeokarst is correlated with a similar one at metre 69 of the western section, where rudstones and fine siliciclastics occur. Siltstones, sandstones and silty/sandy calcarenites absent below metre 69 occur from this horizon upwards.

The sedimentological analysis of the rudstone units of figure 2, reveals that they constitute five distinct packages respectively spanning from metres: 12 to 22, 43 to 50,

**Fig. 2.- Stratigraphic sections of the Albian Cuchía quarry limestones. Note the colouring of the coral boundstones in blue, the bioclastic rudstones in green, both exclusive of the western section, and the predominance of *Bacinella micrites* (yellow colour) in the eastern section. F1 to F14 represent facies types.**

***Fig. 2.- Correlación estratigráfica entre las secciones albienses de la cantera de Cuchía.***


1.5 km
EASTERN SECTION
WESTERN SECTION
"Punta de la Cal"
"Punta de Marzán"
Palaeokarst (calcarenite fill)
Requieniid, caprinid and Chondrodonta bioherm
Palaeokarst
Caprinids
Palaeokarst (coarse calcarenite fill)
Requieniid biostrome (large requieniids)
Requieniid biostrome (large requieniids)
Palaeokarst (breccia fill)
Chondrodonta bioherm
Monopleurid bouquets
Requieniid biostrome
Palaeokarst (siltstone and sandstone fill)
Palaeokarst (sandstone fill)
Giant massive corals and large requieniids (intercalated requieniid biostrome)
Hardground
Tidal bar
Palaeokarst + erosional channel
Palaeokarst
Big massive corals
Palaeokarst
Palaeokarst
Palaeokarst (coarse calcarenite fill)
FAULT
Micritic limestones (F1)
Chondrodonta boundstones (F5)
Laterally discontinuous orbitolinid-rich marly partings (mainly within F6 and F7)
Bacinella micrites (F2)
Fine packstones (F6)
Nodular marls and calcareous marls (F9)
Silty and sandy calcarenites (F12)
Coral boundstones (F3)
Fine-medium grainstones (F7)
Wavy/ nodular calcarenites (F10)
Sandstones and siltstones (F13)
Rudist boundstones (F4)
Medium-coarse grainstones and rudstones (F8)
Silty and sandy wavy/ nodular calcarenites (F11)
Sandstones and siltstones (Bielva Fm.) (F14)
Sponges
Bivalves
Chondrodonta
Serpulids
Coal
Massive corals
Monopleurids
Ostreids
Orbitolinids
Black pebbles
Ramose corals
Requieniids
Brachiopods
Miliolids
Ferruginous crust
Planar corals
Caprinids
Echinoids
Burrows
Vuggy porosity
Gastropods
Polyconitids
Crinoids
Borings
Cross-bedding
Nerineids
Radiolitids
Bryozoans
Amber
Erosional surface

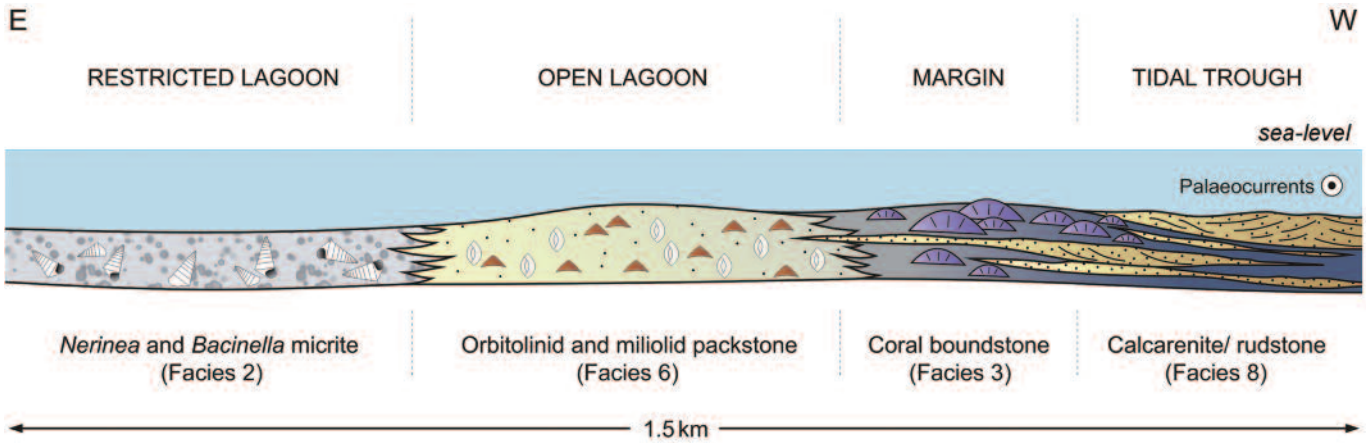



**Fig. 3.-Sedimentary facies model of the Albian Reocín Formation, in the Cuchía quarry (Cantabria). Four palaeoenvironments are recognized, from east (platform interior) to west (platform margin).**

***Fig. 3.- Modelo sedimentario de facies del Albiense de la cantera de Cuchía, con representación de cuatro paleoambientes deposicionales desde mar somero restringido hasta margen de plataforma.***

69 to 76, 82 to 100 and 102 to 103.5 in the western section.

The sedimentology of the rudstone units shows that they characteristically rest onto palaeokarst surfaces.

The rudstones are high-energy tidal bar deposits with large-scale cross-bedding (e.g., metre 96 to 100 of Fig. 2, western section). They are interpreted as transgressive deposits succeeding sea-level falls represented by subaerial platform exposure surfaces (Fig. 3). Similar wedge-shaped calcarenites filling a sedimentary trough have been described in the early Aptian of Aralar (Desamendi calcarenites, Millán *et al.*, 2005). Analogous sedimentary architectures are described in the Aptian of the Galve sub-basin where TST calcarenites are restricted to incised-valley fills (Peropadre *et al.*, 2013).

## Facies model

We have built a facies model for the Cuchía quarry (Fig. 3) that includes four sedimentary environments ranging from more restricted carbonate platform in the east to more open carbonate platform conditions in the west. The *Nerinea* and *Bacinella*/miliolid micrites correspond to a restricted lagoon environment with local bioherms composed of monopleurids or *Chondrodonta* sp. They are laterally interfingered with orbitolinid and miliolid packstones of more winnowed, less restricted lagoonal settings. The third palaeoenvironment corresponds to a bioconstructed margin composed of coral boundstones. The boundstones range to the west into a slope trough dominated by calcarenites deposited along a narrow strait (up to 1 km wide) with palaeocurrents running parallel to the margin and moving preferentially northwards as a result of tidal action. The palaeogeographical offshore direction was towards the North, therefore the trough filling palaeocurrents run from south to north and would correspond to ebb tidal currents (Fig. 3). This trough was an elongated feature running N-S, approximately along the present-day Saja river course. Similar calcarenitic troughs although much bigger in size and connecting two seas, are described between the Atlantic and Mediterranean during the Miocene, exhibiting giant dunes moved by tides along funnelled passages (Martín *et al.*, 2014).

## Conclusions

In the Albian, the shallow seas of the north Cantabria were subdivided in distinct sedimentary environments with specific facies associations and benthic biotas. Rapid facies lateral variations from restricted lagoon to open lagoon, margin and tidal trough are recognized. They are used to decipher palaeoenvironmental relationships.

A facies model is constructed reflecting platform interior to platform margin transition across a 1.5 km distance. The margin location with slope and trough calcarenite fills is controlled by a supposed tectonic line. Large-scale cross-stratification is a distinctive feature of sediments of this ancient tidal strait. Unidirectional palaeocurrents reflect migration of dunes promoted by ebb tidal currents.

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