Inoceramids in the Plentzia Fm. (Upper Cretaceous, Basque-Cantabrian Region): Preliminary Isotopic and Geochemical Data

Datos Geoquímicos e Isotópicos Preliminares de los Inocerámidos de la Fm. de Plentzia (Cretácico Superior, Región Vasco-Cantábrica)

J. Elorza and F. García-Garmilla

Dpto. de Mineralogía y Petrología. Univ. del País Vasco. Apartado 644. 48080 Bilbao

RESUMEN

Se han realizado análisis isotópicos de $\delta^{18}O$ y $\delta^{13}C$ de diversas muestras de calcarenitas y bivalvos inocerámidos (Inoceramus), así como el contenido en ppm (Sr, Co, Cd, Cu, Fe, Mn, Mg, Zn, Ca, Na y Ba) mediante microsonda electrónica en cinco diferentes niveles establecidos en las conchas de inocerámidos y dos en las de ostreidos (Pycnodonte) de la Fm. de Plentzia (Cenomaniense medio-Santoniense inferior), al norte de Bilbao. Los valores isotópicos del $\delta^{18}O$ evidencian una diagénesis temprana, ya que los resultados de paleotemperaturas obtenidos (28.4° C de promedio) son claramente superiores a los valores normales en aguas oceánicas dados por otros autores. A su vez, los datos de microsonda han puesto de manifiesto la tendencia geoquímica hacia un extraordinario empobrecimiento en ppm (Sr, Mg, Fe y Mn) dentro de los distintos niveles establecidos en la concha prismática de los inocerámidos y las capas foliadas y vesiculares de los ostreidos.

Key words: *Inoceramids, oxygen and carbon isotopes, microprobe, diagenesis, Basque-Cantabrian Region, upper Cretaceous.*

Geogaceta, 12 (1992), 93-95.

ISSN: 0213683X

Introduction

The Plentzia Fm. (middle Cenomanian-lower Santonian) was located by Mathey (1982,87) in the north limb of the Bizkaia Synclinorium, specifically the Plentzia-Barrika area in the Basque-Cantabrian Region (fig. 1). This unit has been interpreted as deposited in a middle-outer part of a submarine fan in a carbonate turbiditic environmental complex. The total thickness is very difficult to estimate due to the intense folding affecting it, but it seems reasonably close to 800 m maximum.

The Tb, Tc and Td intervals of Bouma's turbidite sequence of the Plentzia Fm. are mainly composed by calcarenite and calcisiltite rocks. The horizons oscillate from several centimeters to half a meter thick. A thin micritic limestone usually crowns the turbiditic sequence.

From lower to upper three parts can be distinguished in the Plentzia Fm.: a) the basal zone without chert; b) an intermediate part bearing bedded and nodular chert, and c) a less-turbiditic marl enriched upper part. The thinner calcarenite is towards the top, the less-developed silicification will be at the upper part of the unit. Near the top, the silicification is completely softened in marly horizons bearing plenty of inoceramids and oysters *(Pycnodonte)* (Elorza *et al.*, 1991).

The Plentzia Fm. is directly overlaid by the Eibar Fm. (800-1.000 m, Santonian-upper Campanian), which is composed by sandstone and micaceous argilite alternating with calcareous siltstone or grayish marlstone (sandy flysch). Its lower limit is strongly affected by folding and faulting, so it is a tectonic contact with the Urgonian and Supraurgonian sediments (middle Albian to lower Cenomanian).

The Plentzia Fm. vertically evolves to a gradual diminution in carbonate turbidites which implies a subsequent increase in the marly terms. The turbidites only consist of parallel-laminated thin beds or laminae of 1-3 cm thick, and some of them are wedge-shaped. Chert can be most commonly found in very thin laminae following the primary lamination of the rock, but, in general, the silica disappears because of the lack of a sufficient amount of sponge spicules. The marly microfacies consists of a wackestone bearing planktonic foraminifera, radiolarians and fragments of sponge spicules.

Inoceramid and oyster location

A large number of non-silicified *Inoceramus* (complete shells and fragments with thick and weak walls), and some small specimens of *Pycnodonte* appearing together with the inoceramids can be found in the marly sediments (fig. 2). Under the microscope, the typical prismatic microstructure of the inoceramid shells and the composite foliated and vesicular of the oysters can be well appreciated (fig. 3a, b). An ill-developed silicification (quartzine-lutecite spherulites) can be observed in a few inoceramid fragments.

Oxygen and carbon isotopic data

We have determined the $\delta^{13}C$ and $\delta^{18}O$ contents of 22 samples (calcarenites and *Inoceramus* prisms) taken from the Plentzia and Eibar Fms., in the Barrika cliffs. These data have been plotted against a lithology section to indicate stratigraphic trends (fig. 4). Oxygen and carbon isotopic values clearly show variations and defined trends through the sequence. In general, the «excursions» or spikes agree with the already known compositional differences in the bulk sediment.

The oxygen isotopic values of *Inoceramus* prisms can be used for estimating paleotemperatures. If they show no diagenetic recrystallization, then, their oxygen isotopic values are considered to represent the original environmental signal of the bottom water (Pirrie and Marshall, 1990; Schönfeld *et al.*, 1991). But, if the oxygen isotopic composition of *Inoceramus* prims has more negative values than the relative bulk sediment, recrystallization of skeletal carbonate under conditions of burial diagenesis is suggested.

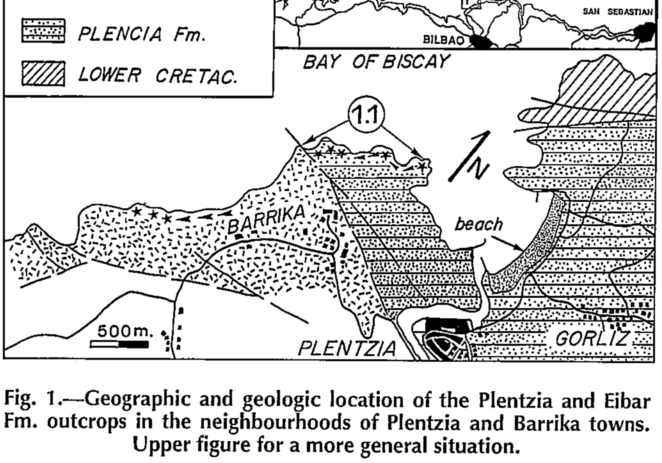

Fig. 1.—Geographic and geologic location of the Plentzia and Eibar Fm. outcrops in the neighbourhoods of Plentzia and Barrika towns. Upper figure for a more general situation.

Fig. 1.—Mapa de situación geográfica y geológica de los afloramientos de las Fms. de Plentzia y Eibar en la zona de Plentzia-Barrika. La figura superior muestra un sector más amplio.

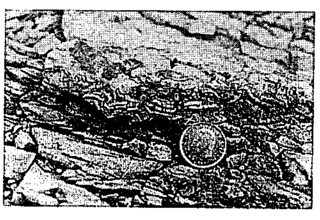

Fig. 2.—Broken inoceramid shells together with small oysters (*Pycnodonte,* arrowed).

Fig. 2.—Conchas rotas de inocerámidos y pequeños ostreidos (*Pycnodonte*, señalado con la flecha).

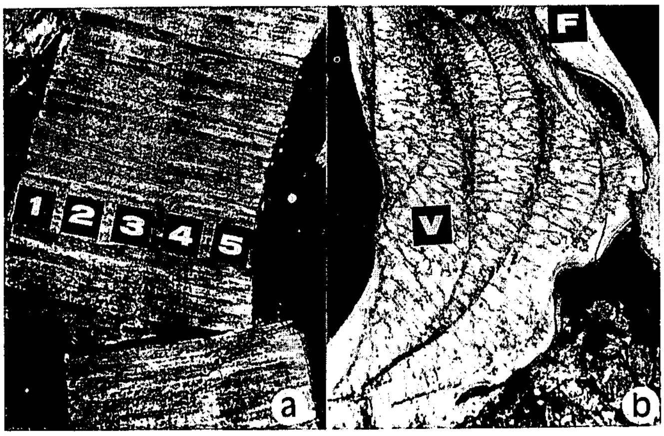

Fig. 3.—a) the typical prismatic microstructure of the inoceramid shells has been analyzed in five different zones (1-5). The growth lines can be seen. PPL. Photo width: 3.1 mm.; b) the complex alternance of vesicular and foliated microstructures in an oyster shell. PPL. Photo width: 3.1 mm.

Fig. 3.—a) microfotografía de la concha prismática de un inocerámido mostrando los cinco niveles establecidos (1-5). Se aprecian bien las líneas de crecimiento. Luz normal. Anchura de la foto: 3,1 mm.; b) alternancia compleja de microestructuras foliadas y vesiculares en la concha de un ostreido. Luz normal. Anchura de la foto: 3,1 mm.

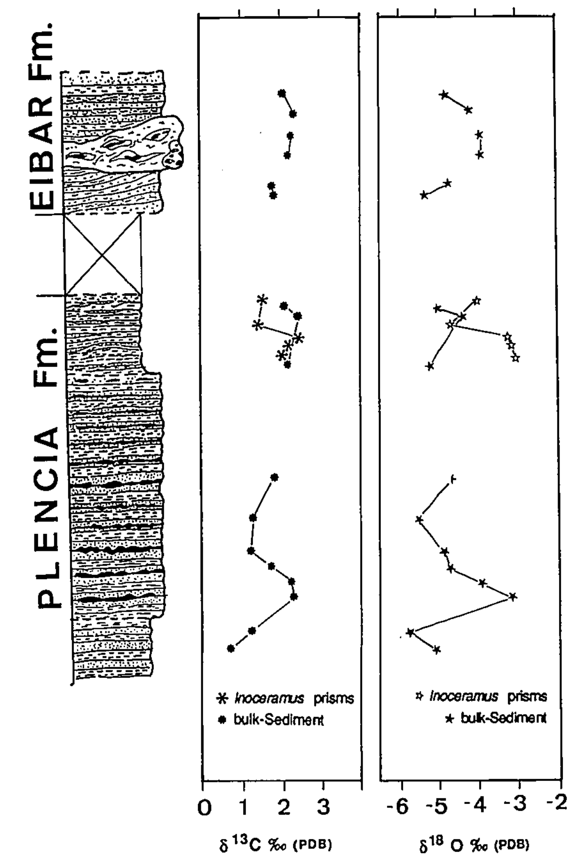

Fig. 4.—Carbon and oxygen stable-isotopic distribution of carbonate turbidites, *Inoceramus* prisms, siliciclastic turbidites (sandy flysch) plotted against the lithostratigraphy of the Plentzia and Eibar Fms.

Fig. 4.—Distribución de los isótopos estables del carbono y el oxígeno en las turbiditas carbonatadas, prismas de* Inoceramus *y turbiditas siliciclásticas (flysch arenoso). Los resultados se sitúan en la columna estratigráfica de las Fms. de Plentzia y Eibar.

The $\delta^{18}O$ values obtained from the *Inoceramus* prisms in the Plentzia Fm. are generally heavier (with a mean of $\delta^{18}O = -3.64$‰ PDB) than the bulk sediment (calcarenite) with a mean of $\delta^{18}O = -4.88$‰ PDB. For this reason, the *Inoceramus* prisms can be considered for the moment as unaffected by diagenesis.

The paleotemperatures calculated by using *Inoceramus* isotopic values and the equation of Yapp (1979) for the Plentzia Fm., range from 25.6° to 33.7°C with a mean value of 28.4°C. These temperatures could be produced by an early diagenetic modification, because they are higher than the values of 12-19°C (with a mean temperature of 16°C) obtained by Schönfeld *et al.* (1991) for the Upper Cretaceous Chalk (upper Campanian-lower Maastrichtian) at the Lagerdorf section (NW Germany). Pirrie and Marshall (1990) obtained a mean value of 13.6°C from *Dimitobellus* (a nektonic belemnite). However, the 26°C mean temperature obtained from *Inoceramus* in the late Cretaceous of James Ross Island (Antarctica) by the same authors is thought to have been modified by pore waters expelled from the underlying compacting volcaniclastic sediments.

Geochemical data

Several inoceramid shell fragments have been analyzed under automatic Camebax microprobe in five different zones across the shell: 1. external; 2. middle-external; 3. middle; 4. middle-internal; 5. internal, amounting to 23 analysis (fig. 3a, table I). In the same way, a total of 9 measurements were carried out upon the oyster fragments; concretely 4 corresponding to foliated microstructures and 5 to vesicular ones (fig. 3b). Both inoceramids and oysters are actually composed by low magnesium calcite (0.75-1.01 mol% $MgCO_3$ and 0.42-0.92 mol% $FeCO_3$ + $MnCO_3$ versus 98.07-98.57 mol% $CaCO_3$).

No significative or organized trends can be appreciated in the Sr content (from 5 to 13.5 ppm), Mg (the second in abundance, 85.5-104.1), Fe (12.5-40) and Mn (21.8-51.3) from external to internal parts of the inoceramid shells (table I). But curiously the minor components, with slight deviations, show a gradual decrease from outer to innermost parts of the shell (Cd from 12.7 to 0.1 ppm, Cu 14.4-0.2, Zn 11.6-2.9, Co 12.6-0.0 and Ba 15.3-3.6 ppm). Finally, the Na content draws a Gauss-curve-like distribution, with a maximum in the third zone (121 ppm) and the minimum values in the outermost (9.6) and innermost (29.6 ppm) zones. Ba and Na are higher in the middle part of the shell. Clearly a very pure composition in calcite is the most relevant geochemical feature of the Barrika inoceramids, with a very low proportion of other cations, unlike the Mg, Fe, Sr and Mn mean values of the James Ross Island specimens, which are overwhelmingly enriched (Mg: 5,460 ppm; Fe: 805; Sr: 1,414 and Mn: 236, fig. 5).

In the same way, the vesicular zones of the oyster shells have lesser proportions of cations than the foliated ones, except for the increase of Fe (from 27.8 to 58.7 ppm) and Na (31.4-39.3) (fig. 5, table I). Ca again is the most representative cation (more than 9,700 ppm). As can be seen from the observations under cathodoluminiscence, the inoceramid and oyster shells show bright yellow colours (calabash-like) reinforcing the minimum content in Mn.

SAMPLE	Exter. Z. Inoc.	Middle /ext.	Middle Zone	Middle-Inner	Inner Zone	Foliated estr.	Vesicular estr.
Chemical analysis	n=8	n=2	n=3	n=5	n=5	n=4	n=5
Calc. %	98,528	98,525	98,404	98,068	98,240	98,536	98,459
Mag. %	0,828	1,056	0,987	1,015	1,014	0,844	0,754
Sid. %+Rod.%	0,643	0,418	0,609	0,917	0,745	0,620	0,787
Sid. %	0,331	0,188	0,126	0,402	0,402	0,278	0,592
Rod. %	0,312	0,231	0,483	0,516	0,343	0,343	0,195
VALUES IN PPM							
Sr ppm	7,721	13,511	7,238	5,018	9,844	13,993	6,562
Co ppm	3,336	12,678	6,006	5,338	0,000	7,007	4,004
Cd ppm	12,752	6,230	1,947	2,648	0,156	2,726	2,804
Cu ppm	14,456	7,542	2,514	0,251	1,006	5,028	1,760
Fe++ ppm	34,273	17,397	12,526	40,084	40,084	27,836	58,733
Mn ppm	32,422	21,849	48,633	51,311	34,395	34,184	19,453
Mg ppm	85,565	104,167	100,446	101,190	101,190	84,325	73,909
Zn ppm	11,671	7,985	5,528	2,948	4,423	3,993	2,948
Ca ppm	10093,170	9536,377	10006,241	9755,706	9807,775	9864,479	9754,993
Na ppm	9,680	19,360	121,003	74,860	29,686	31,461	39,366
Ba ppm	1,304	0,000	15,327	9,914	3,652	4,566	3,000

Table I.—**Geochemical data (mean values in ppm and mol %) of inoceramids of the Plentzia Fm.**

Tabla I.—**Valores medios geoquímicos en ppm y % molar de los inocerámidos de la Fm. Plentzia.**

Conclusions

Frequently the Barrika inoceramid original shell architecture is well-preserved, and the growing layers are clearly visible. Nevertheless, from the geochemical, isotopic and petrographic data (i.e: silicification and cathodoluminis-

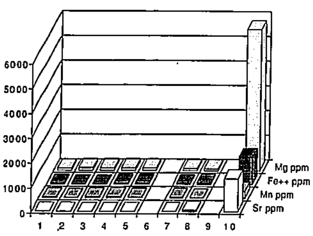

Fig. 5.—Sr, Mn, Fe and Mg ppm values of inoceramids (files 1-5), oysters (files 7-8) and the inoceramids of James Ross Island (Pirrie and Marshall, 1990, file 10).

Fig. 5.—Valores del Sr, Mn, Fe y Mg en ppm para los inocerámidos (filas 1-5), ostreidos (filas 7-8), e inocerámidos de James Ross Island (Pirrie and Marshall, 1990, fila 10).

cence), it seems very reasonable to think that the diagenetic modification has affected the inoceramid and oyster shells in some way, causing certain chemical differences depending on the several shell layers and obliterating the vital composition of the pristine state.

Waiting for future results, these comparative data are not in disagreement with a certain diagenetic degree affecting the Barrika specimens and causing a relative cationic impoverishment with the exception of diagenetic calcite. From our thin section observations, the neomorphism is morphologically negligible, so the diagenetic influences were probably very low. The original arrangement of the prisms is unaffected, saving the compaction effects. In this way, the diagenetic evolution reflects a geochemical modification of the inoceramid shells rather than a textural one.

Acknowledgements

To Drs. J. J. Pueyo and C. Taberner (Universidad Central de Barcelona) for their facilities in the carbonate isotope analysis. To Dr. M. Veschambre (Université Blaise Pascal, Clermont-Ferrand) for the kindness and support during the electron microprobe tests. To Mr. Zacarías Alvarez for the photographic work. This work has been financed by a Research Project of the Universidad del País Vasco (UPV 130.310-E136/91).

References

Elorza, J. *et al.* (1991): *VIth International Flint Symposium. Excursion Guidebook*, 1-92.
Mathey, B. (1982): *El Cretácico de España. Univ. Complutense. Madrid*, 111-136.
Mathey, B. (1987): *Mem. Geol. Univ. Dijon*, 12, 399 pp.
Pirrie, D. and Marshall, J. D. (1990): *Palaios*, 5, 336-345.
Schönfeld, J. *et al.* (1991): *Cretaceous Research*, 12, 27-46.
Yapp, C. J. (1979): *Geochem. Cosmochim. Acta*, 43, 629-635.

Zonación ambiental de «mounds» algales del Carbonífero de la Zona Cantábrica (NO de España)

Paleoenvironmental distribution of algal mounds in the Carboniferous of the Cantabrian zone (NW Spain)

L. P. Fernández y P. Barba

Departamento de Geología (Area de Estratigrafía). Universidad de Oviedo. C/ Arias de Velasco, s/n. 33005 Oviedo.

ABSTRACT

Limestones are conspicuous within the shallow water rocks of the Carboniferous (Namurian-Westphalian) foreland basin sequences of the Cantabrian Zone. These limestone bands, containing oustanding algal bioherms, show a well defined facies spectrum with three main boundstone facies (Donezella *boundstone,* Tubiphytes-*briozoa boundstone and phylloid algae boundstone). Both the entire facies association and, more specifically, the algal boundstone facies show a pattern of distribution which seems to reflect the interplay amongst several environmental factors. Water depth and delta-derived efluents and its fine terrigenous (clay) suspension load are thought to have been the main controlling features through their influence in other parameters such as bottom energy, salinity and depth/ligth distribution and bottom illumination.*

Key words: *Cantabrian Zone, Carboniferous, algal mounds, environmental parameters.*

Geogaceta, 12 (1992), 95-97.
ISSN: 0213683X

Introducción

Durante el Carbonífero la Zona Cantábrica (fig. 1) constituyó una cuenca de antepaís situada por delante del orógeno varíscico. En esta cuenca se registran varias etapas de relleno (secuencias) que en el caso ideal abarcan desde ambientes relativamente profundos hasta ambientes continentales. Los ambientes de plataforma somera estuvieron dominados por la sedimentación de los materiales terrígenos procedentes del orógeno vía aparatos deltaicos. Episódicamente en estos ambientes se produjo la instalación de plataformas carbonatadas. Las plataformas carbonatadas presentan típicamente base erosiva sobre los terrígenos y techo gradual a facies de lutitas de plataforma/prodelta; más raramente son cubiertas de modo abrupto por sedimentos de ambientes más profundos identificados con una plataforma externa. Estas relaciones sugieren que la instalación de las plataformas carbonatadas se produjo tras una transgresión asociada a la cual se desarrolló una superficie erosiva; la finalización de la sedimentación carbonatada se correlaciona con un incremento en la entrada de terrígenos debido a la progradación de aparatos deltaicos o por una repentina profundización del medio.

Facies carbonatadas

Los niveles calcáreos de edad Namuriense y Westfaliense a nivel de toda la Zona Cantábrica, presentan una asociación de facies bastante uniforme (Bowman, 1979, 1985; Fernández, 1990; Barba, 1991) en la que destacan las facies bioconstruidas (figs. 2 y 3). Estas dieron lugar a «mounds» de extensión areal variable entre decamétrica y hectométrica y potencia decimétrica a decamétrica. En este trabajo se muestran cuatro de las secciones más representativas de estos niveles.

El armazón de las plataformas carbonatadas está formado principalmente por tres facies entre las cuales se intercalan las construcciones algares. La facies más común es la wackestone bioclástica, que consta de bioclastos de fauna y flora de carácter marino, variada y abundante, inmersos en una matriz de micrita no ferrosa y relativamente pobre en arcillas. Hacia el margen interno de las plataformas aquella facies evoluciona a la wackestone escasamente fosilífera, mediante una disminución en la cantidad y variedad de organismos, que por otra parte aparecen menos fragmentados y se engloban en una matriz de micrita ferrosa y más rica en arcillas que en el caso de la facies anterior. Finalmente, en el borde interno de las plataformas la aparición de nódulos algares unida a un aumento en la proporción de arcillas en la matriz de micrita ferrosa supone la aparición de la facies de wackestone de nódulos algares.

Las construcciones algales

Por lo que respecta a las bioconstrucciones, los organismos responsables de su génesis fueron principalmente distintos tipos de algas. Tres facies (asociaciones ecológicas) se distinguen en base al estudio microscópico de las calizas bioconstruidas: