Synsedimentary diapirism in the Cueva Formation at El Ribero sector, Burgos (Upper Cretaceous, Basque-Cantabrian Basin, Northern Spain)

Diapirismo sinsedimentario en la Formación de Cueva en el sector de El Ribero, Burgos (Cretácico Superior, Cuenca Vasco-Cantábrica, Norte de España)

M. Erkia; F. García-Garmilla; A. Aranburu y J. Elorza

Departamento de Mineralogía y Petrología, Facultad de Ciencias, Universidad del País Vasco, Apdo. 644, 48080 - Bilbao, Vizcaya (Spain)

RESUMEN

En este trabajo se aborda el análisis secuencial y tectosedimentario de las dolomías de la Formación de Cueva (Turoniano sup.-Coniacien inferior; 80 m. de potencia máxima) que afloran en el sector de El Ribero (Burgos, norte de España). La unidad consta de bancos carbonatados de hasta 30 m. de potencia que normalmente son masivos, pero, en este lugar, presentan cinoformas que buzan en sentidos opuestos a partir de la zona central del diapiró de Rosfo, dibujando una estructura domal en su conjunto. Las dolomías aparecen justo por debajo de una superficie de ruptura de primer orden (CSB, Límite Secuencial del Coniacien) y se restringen a la zona de halocinesis. Su techo es plano, pero la base es de geometría irregular, lo que sugiere un movimiento descendente de los fluidos dolomitizantes. Como consecuencia de los pulsos diapíricos, se formaron varios horizontes de paleokarst con estructuras de colapso y cavidades rellenas por sedimentos laminados del tipo «cul de sac». Estos rasgos llevan a pensar que los movimientos diapíricos pudieron haberse producido sinsedimentariamente y fueron especialmente activos durante el tiempo de depósito de la Formación de Cueva.

Key words: Upper Cretaceous, Basque-Cantabrian Basin, carbonate ramps, cinoforms, synsedimentary diapirc activity.

Geogaceta, 19 (1996), 15-18
ISSN: 0213683X

Introduction. Geological setting

After the widespread Cenomanian-Turonian anoxic event (Jenkyns, 1980) that marks the deepest deposition in the Castilian platform, a relative fall in sea-level occurred with the subsequent creation of shallow carbonate ramps, of which many have sedimentary ruptures. The upper Turonian-Lower Coniacian series (Fig.1) in the Castilian platform domain (Feuillée, 1967) are represented from bottom to top by the Hornillalatorre, Cueva and Nidáguela Formations (Floquet et al., 1982; Amiot, 1982; Floquet, 1991). Our interest is focused on the Cueva Formation (50-80 m., late Turonian-early Coniacian), which consists of well-bedded, fine to medium-grained bioclastic packstone to grainstone, massively-bedded in the lower part (in one unit up to 30 m.) and more discretely in horizons of a few meters thickness towards the top. Fossils are not easy to identify, but corals, sponges, red algae, pectinoids, inoceramids, oysters (Pycnodonte) and some bioturbation (Thalassinoïdes) are frequent in the upper part of the unit. The presence of lithoids and millioids was recorded among the foraminiferal content. Locally, the Cueva Formation is strongly dolomitized («El Ribero Member», IGME, 1978; Floquet et al., 1982). Although normally massive or poorly structured, the Cueva Formation exhibits progradational morphologies (cinoforms) in the vicinity of the Rosfo diapir (El Ribero sector). The features mentioned above seem to be compatible with an open platform environment, which includes characteristics of tidal facies: bipolar cross-laminated and cross-bedded bioclastic calcarenites.

Stratigraphy and sequential analysis

The Cueva Formation is intensely dolomitized near the town of El Ribero (Figs.1 and 2), where the lateral and vertical changes from dolomitized to non-dolomitized rock are easily visible. Field and petrographic evidence reveal the existence of two first-order depositional sequences (DS1 and DS2, Fig.2), which resulted from major eustatic sea-level changes. The lower part of the Cueva Formation is represented by the High Systems Tract of the lower sequence (CHST=Coniacian High Systems Tract), and the upper part of the unit (Ribera Alta Member) corresponds to the Transgressive Systems Tract of the upper sequence (CTST=Coniacian Transgressive Systems Tract). The boundary between CHST and CTST is a type-1 sequence boundary (Floquet, 1991) (CSB=Coniacian Sequence Boundary, Fig.2). Whereas the CHST consists of cinoforms prograding both to the north and south, the CTST is a top-lap sequence, which lies with angular unconformity upon the CHST. Other minor sedimentary gaps also appear in the El Ribero section. Two
indicative of a small platform model related to diapir-originated highlands are present. Close to the diapir, several tens of meters of the sedimentary pile have been intensely dolomitized (Ertkia et al., this volume), although sedimentary structures such as cross-lamination and algal mats and fossils such as corals and brachiopods, have been preserved. The lower limit of the dolomitized mass is irregular and easily visible at the south of El Riberó, whereas the upper limit is horizontal and follows the CSB sequence boundary. Dolomitization laterally disappears towards the north of the diapiric dome, not in a sharp manner, but accurately following the clinoform planes that may have allowed the circulation of dolomitic fluids. The northernmost dolomite facies appear as thin wedge-shaped pure dolomite horizons interbedded between thicker calcarenite beds. During the late CHST, several coral patch reefs developed, which have subsequently been largely dissolved, although some were partially preserved by silification. The CSB sequence boundary at the top of CHST can be correlated with that of 88.5 my by Haq et al. (1988). The same limit has been referred to as SB-8 by Floquet (1992) and UC-10 by Grafé & Wiedmann (1993) in wider areas of the Basque-Cantabrian Region.

The upper depositional sequence (DS2) outcrops as a subhorizontal calcarenite unit that unconformably overlies the clinoform system of the CHST. At the base of the shallowing-upwards cycles are poorly-structured limestone beds that vertically evolve to cross-laminated, cross-bedded and fossiliferous calcarenite beds. At the very top, shallowing features are still conspicuous: small quartz geodes and quartz-filled desiccation cracks in two particular horizons, which have been interpreted as two minor sedimentary gaps restricted to the El Riberó area. The most shallow horizons are marked by oyster concentrations very similar to those described for Urgonian sediments in the Basque Cantabrian Basin (Rosales, 1995). The transition to the upper Nidágui Formation is represented by a thick calcarenite bed, bearing glauconite, and denotes a sharprise of sea-level, since this formation is marly and echinoderm and oysters are the most commonly preserved fossils. The host limestone largely consists of shallow marine packstone/grainstone bearing millo-

---

**Fig. 1.- Geographic location and geologic map of the Cueva Formation at El Riberó showing the stratigraphic sections A-A' and B-B'.**

**Fig. 1.- Localización geográfica y mapa de afloramientos de la Formación de Cueva en El Riberó. Se indican las secciones estratigráficas A-A' y B-B' de la unidad.**

Minor sequence boundaries outcrop very close to each other in the lower part of the Cueva Formation. Both boundaries have erosional features; the lower exhibits scours and fill surfaces and the upper reveals evidence for paleokarstification, such as vugs with laminated infillings and collapse structures. Fifteen metres below the CSB, a third minor sequence boundary has a smooth and flat upper surface, which bears cauliflower-type quartz geodes associated with anhydrite relics. Such minor boundaries were not found in equivalent sections nearby, such as at Cueva and Bedón Mountain (Elorza and García-Garmilla, 1993, 1995), which suggests that they may have had an origin related to local diapiric synsedimentary movements.

The base of the lower depositional sequence (DS1) contains the deepest marly facies of Upper Cretaceous sediments in the Navarro-Cantabrian domain (Hornillalatorre Formation), and is topped by metre-scale shallowing-upwards cycles (early CHST). A scour and fill sequence boundary appears at the top of the last parasequence. Karstification affected the shallow deposits overlying this boundary and involved a vadose zone whose thickness can be estimated to be about 3.5 m. The late CHST is spectacularly developed and is characterized by clinoforms dipping towards both N and S (Figs. 2 and 3). The HST carbonate body is tabular-shaped, with roughly parallel lower and upper boundaries, although opposite and variable inclinations in some places indicate tilting, possibly related to halokinetic movements of the adjacent Rosío diapiric zone (García-Garmilla and Elorza, 1991; Elorza et al., 1991). Some minor gaps in the clinoform system can also be detected.

A general carbonate ramp setting is likely for the Cueva Formation (e.g., Sarg, 1988), but features (clinoforms)
Fig. 2.- The sections A-A’ and B-B’ of the Cueva Formation with indication of stratigraphic profiles and four detailed views (a, b, c, d) of concrete zones of the clinoforms (see text).

Fig. 2.- Secciones A-A’ y B-B’ de la Formación de Cueva con la localización de los perfiles estratigráficos, así como cuatro esquemas de detalle (a, b, c, d) de otras tantas zonas concretas de las clinoformes (ver texto).

Geometry of carbonate bodies

Normally the Cueva Formation is composed of horizontal to subhorizontal massive banks up to 30 m in thickness. This character changes at El Riberó to prograding clinoform systems. Clinoforms are sigmoidal to oblique, and generally dip about 5°, but may dip up to 10° near the diapir, as described by Gawthorpe and Gutteridge (1990) for the Dinantian in the UK. They exhibit in general a tabular geometry, having their upper and lower surfaces more or less parallel. The observations at the W of the studied area (Bedón Mountain) show the progradation of clinoforms towards the W. Overall, these observations suggest that the clinoforms assumed a dome-like structure having the central area just coinciding with the diapiric body (Fig.3).

Although the actual diapiric outcrop area is like an „L“, the isobath maps (BRNESA, 1990) reveal that the Rosio diapir has an enlarged E-W domal shape. Just at the point „a“ in Fig.2, contrary dips at local scale have been recorded suggesting depressions caused by differential halokinetic movements. As Fig.2 shows, the clinoforms become horizontal at points „b“ and „c“ in Fig.2, whereas the higher dip appears at „d“. Higher dips indicate the predominance of aggradational stages in the behaviour of the platform, whereas the lower ones („b“ and „c“) should denote a significant progradation. The progressively more gentle dips towards the north of the studied area seem to prelude the relative fall in sea level marked by the Coniacian Sequence Boundary (CSB).

The complete set of clinoforms has a thickness close to 80 m and the progradation develops along 9 km. In spite of the fact that the number of collected samples is not enough at present, it seems likely that the organic build-ups (silicified corals) are installed at the upper part of the clinoforms, whereas the lower part is largely composed of bioclastic detrital sediments. Field observations support a model of „horizontal progradation“ similar to that described by Bosellini (1984) for the Catuccio platform (Triassic, Northern Italy), but on a much smaller scale.

Relations with synsedimentary diapirism

The Cueva Formation carbonates were deposited in a widespread
carbonate ramp, but locally and close to
the actual diapiric area of Rosio, the
behaviour of the system was similar to
a small platform. The observations at
higher scales (Fig.3) seem to
corroborate this point. The clinoforms
in Western points (Bedón Mountain)
clearly dip towards the W. This points
to a general domal shape for the
clinoforms as a whole.

Dolomitization and calcitization in
the most emerged zones of the area
of diapiric influence reveal diagenetic
environments related to shallow marine
followed by fresh-water meteoric
domains. The presence of evaporitic
nODULES in such horizons reinforces
the idea of a significant shallowing at this
point (Erkiga et al., this volume). In
addition, dolomitization diminished
in the most distal areas of the
diapir and appeared as wedges of
infiltration in the northernmost places.
Taking into account the opposite dips
at El Riberó and the concentration of
dolomite and meteoric calcite in the
sediments at the diapiric zone, the most
probable mechanism invoked for the
development of the Cueva Formation
clinoforms could be associated with
diapiric local uplifts, whose intensity
and orientation may have varied over
time, provoking contrary dips and
topographic troughs on a minor scale.
This is a unique sedimentologic and
paleogeographic feature, which cannot be
observed in other sections of the Cueva
Formation along the Castilian platform.

Acknowledgements

This paper has been supported by the
Universidad del País Vasco through
the Research Project UPV/EHU
130.310-EB059/93. The authors
express their thanks to David J. Fogarty
for correcting the English version of
the manuscript.

References

Madrid Univ. Complutense, 88-111.
Bosellini, A. (1984) Sedimentology. 31,
1-24.
Elorza, J., García-Garmilla, F., Arriortúa,
International Flint Symposium,
Excursion Guidebook, Madrid, 1-92.
Geological Magazine 130, 805-816.
Serv. Publ. Univ. de Granada-
E.N.R.E.S.A. (1990) Documentos so-
brea la Geología del Subsuelo de Es-
Paña (map).
Erkiga, M., García-Garmilla, F., Aran-
bru, A. & Elorza, J. (Geocaceta,19)
France XLVI, n° 108, 1-343.
Dijon, 14, 1-925.
Book. International Symposium Se-
quence Stratigraphy of Mesozoic-
Cenozoic European Basins, Dijon,
France, 1-130.
Floquet, M., Alonso, A. & Meléndez,
Madrid Univ. Complutense, 387-453.
García-Garmilla, F. & Elorza, J.
(1991).12th. I.A.S. Regional Mee-
Gawthorpe, R.L. & Gutteridge, P.
iment., 9, 39-54.
Gräfe, K.-U. & Wiedmann, J. (1993)
Geol. Rundsch. 82, 327-361.
Haq, B.U., Hardenbol, J. & Vail, P.R.
1:50.000. n° 85 (Villasana de Mena),
1-32.
London, 137, 171-188.
Thesis. University of the Basque
Country, 1-496.