Palaeogeography, Palaeoclimatology, Palaeoecology 367–368 (2012) 219–230

Contents lists available at SciVerse ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Color/facies changes and Global Events, a hoax? A case study from the Lochkovian (Lower Devonian) in the Spanish Central Pyrenees☆

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ARTICLE INFO

Article history:
Received 28 March 2011
Received in revised form 9 August 2011
Accepted 13 September 2011
Available online 21 September 2011

Keywords:
Global Events
Color change
Lochkovian
Spanish Pyrenees
Conodonts

ABSTRACT

Five Pyrenean Lochkovian sections are studied aiming at the recognition of the influence of facies changes in Biotic Global Events. The wealthy conodont record permits precise age control of strata in the different sections, and high-precision correlations, both regional and intercontinental; it also permits identification of major Global Biotic Events for this group of fossils. The comparison of the bio- and chronostratigraphic framework with the different Facies identified in the Pyrenean rocks shows that contrasting color (and facies) changes are not synchronous in the studied sections and that the major Biotic Events are not directly related to relevant facies shifts. These results question the opinion of direct tie relations between strong color changes and Global Events in the Lower Devonian, and reinforce the value of palaeontological tools for Global studies and correlations.

1. Introduction

Walliser (1984) coined the term Time Specific Facies (TSF) as "very specific facies that correspond to very specific facies features that characterize distinct times of the earth history" and pointed out that TSF "may be verified only in a certain palaeogeographic position". The concept was slightly expanded (Walliser, 1996) to connect facies changes with Global Bio-Events, especially for those changes caused by sea-level changes, and by fluctuation of oxygen content of the water mass. These changes can be reflected in the sediments by contrasting colors, different litho- and biofacies features…etc.

It is believed that most of the Global Bio-Events are linked to Litho-Events, as, for instance, strong facies changes (Walliser in Barnes et al., 1996). However, only some of the five major Lower Devonian Global Events (Silurian/Devonian (S/D) Boundary Event, Lochkovian/Pragian (L/P) Boundary Event, Basal Zlichov Event, Daleje Event, Emsian/Eifelian Boundary Event) are linked to marked color and facies changes (Walliser, 1996).

The term "Specific Facies" has largely been used in Historical Geology for a long time maybe without knowing the proposed term TSF. An example is the change of color used for tracing the L/P boundary in the Prague Basin; or, the S/D boundary in the Pyrenees. There the black carbonaceous shale interbedded with black orthoceratid limestone, often containing scyphocrinoids, are considered to be Upper Silurian. Thus, the S/D boundary is traced at the lithofacial change (also reinforced by a color turnover) from this facies to the overlying bedded limestone with mm-cm intercalation of marls and shale (de Villalta and Rosell Sanuy, 1969).

The continuous use of (litho)facies characteristics to globally date rocks and even "global events" without taking into account the palaeontological content, has prompted us to start a study of the litho- and biofacies changes that happened in an area that has no strong differences in the palaeogeographic position and that is well characterized biostratigraphically, so that we have on hand a very detailed and precise geological clock to date the rocks. The assumed precision for some intervals is of several hundreds of thousands of years. Initially, we wanted to characterize the effect of a marked color change around the S/D Boundary on the biota in selected sections of the Spanish Pyrenees, but while analysing this situation, we realised that several Global Biotic Events were involved in a short time-span and, thus, we decided to include them in this general analysis connecting lithological (color and texture) and biological events in several sections that belong to the same palaeogeographical unit.

Therefore, the main goal of this report is to analyse the connection between facies changes and biotic events in a good age-controlled set of five Lochkovian sections from the Spanish Central Pyrenees. Additionally, by checking the potential use of such abiotic changes in global correlations, we test their synchronicity in these Pyrenean sections.

2. Materials and methods

Five Lochkovian sections belonging to the Compte Subfacies Area of the Spanish Central Pyrenees (Mey, 1967a,b; Habermehl, 1970; Zwart, 1979; Valenzuela-Ríos, 1994a; Valenzuela-Ríos and Liao, 2006) have been studied in detail. These sections are currently

☆ Dedicated to the memory of Prof. Dr. Otto H. Walliser.

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0031-0182/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.palaeo.2011.09.007

separated by less than 40 km along strike (Fig. 1) and exhibit some lithological differences that will be commented below, in subchapter 3.2.

Two sections, Gerri 1.1 and Gerri 1.2 (de Villalta and Rosell Sanuy, 1969; Valenzuela-Ríos, 1990, 1994a,b; Valenzuela-Ríos and Murphy, 1997; Valenzuela-Ríos and García-López, 1998), which are separated by a fault, crop out on the west hill of the Noguera Pallaresa River, about 5 km south of Gerri de la Sal (Fig. 1). Section Compte-I is exposed on the western bank of the Noguera Pallaresa River (Ziegler, 1959; Valenzuela-Ríos et al., 2005). Section Baen crops out north of the village of Baen along an unnamed small creek (Boersma, 1973; Valenzuela-Ríos, 1996). Section Segre 1 is exposed along the former National road connecting La Seu d'Urgel with Puigcerda on the north bank of the Segre River (Valenzuela-Ríos, 1994a,b, 2002; Valenzuela-Ríos and Murphy, 1997; Valenzuela-Ríos and García-López, 1998; Murphy and Valenzuela-Ríos, 1999).

All these Lochkovian sections have been sampled in detail (mainly bed by bed) for the most exhaustive Lochkovian conodont biostratigraphic control in pelagic facies in Europe, comparable to similar studies in Central Nevada (USA). In fact, the robust biostratigraphic Pyrenean frame-work permits the first intercontinental correlation between Pyrenean and Nevadan sections and has prompted Valenzuela-Ríos (1994b), Valenzuela-Ríos and Murphy (1997) and Murphy and Valenzuela-Ríos (1999) to propose a new Lochkovian conodont zonation and to informally subdivide the Lochkovian into three parts (lower, middle and upper). This three-fold partition is further subdivided in many conodont zones that are also identified and correlated in northern Spain and western USA. In brief, the fine biostratigraphical framework in the Pyrenees provides a sound basis for further studies.

The new conodont biostratigraphical analysis carried out in this report has revealed the happening of major bio-events (mainly innovation, radiation and extinction events) that are isochronous and globally traceable; therefore they can be considered as Global. They concern the radiation of the genus *Icriodus* in the lower Lochkovian, the innovation, radiation and extinction of the genera *Lanea* and *Flajsella* in the middle Lochkovian, the radiation and extinction of the genus *Ancyrodelloides* in the middle Lochkovian and the radiation of the genus *Pedavis* in the upper Lochkovian.

As one relevant aspect of this paper is trying to tie the Global Bio-Events to major facies changes, color changes in particular, and test isochroneity, the analysis of the sedimentary record is mandatory. In this work, we also describe four main facies by combining microfacies studies and field observations, accurately date them by means of conodonts and, finally, establish a time-rock frame for all these facies in the Pyrenees. This frame is further compared to the prevailing Lochkovian Global Bio-Events described herein.

3. Lochkovian bio and lithostratigraphy from the Spanish Central Pyrenees

3.1. Biostratigraphical framework

The combination of the five selected Pyrenean sections comprises an interval from close to the S/D Boundary to the L/P Boundary. We follow the three-fold Lochkovian Stage subdivision (lower, middle and upper) proposed by Valenzuela-Ríos and Murphy (1997). Further splitting is based on the finer conodont zonation as exposed in several papers (Valenzuela-Ríos, 1994a,b; Valenzuela-Ríos and Murphy, 1997; Murphy and Valenzuela-Ríos, 1999).

Rocks around the S/D Boundary can be analysed in two sections: Gerri 1.1 and Compte-I; the lower-middle Lochkovian Boundary and the subdivision of the middle Lochkovian can be analysed in all sections. The upper Lochkovian subdivision is recognized in four sections (Gerri 1.1; Gerri 1.2; Segre 1 and Compte-I), but the L/P boundary can only be approximated in the latter two sections.

3.1.1. S/D Boundary and lower Lochkovian

The S/D Boundary coincides with one of the minor Global Events and the faunal changes permits its classification as a fifth order Bio-Event (Walliser, 1985). According to House (2002) the S/D Boundary Event cannot be sedimentologically characterized. However, Walliser (1996) recognized a sea-level rise in several sections from the Barrandian, the Carnic Alps, Sardinia and the Moroccan Meseta; all of them belonging

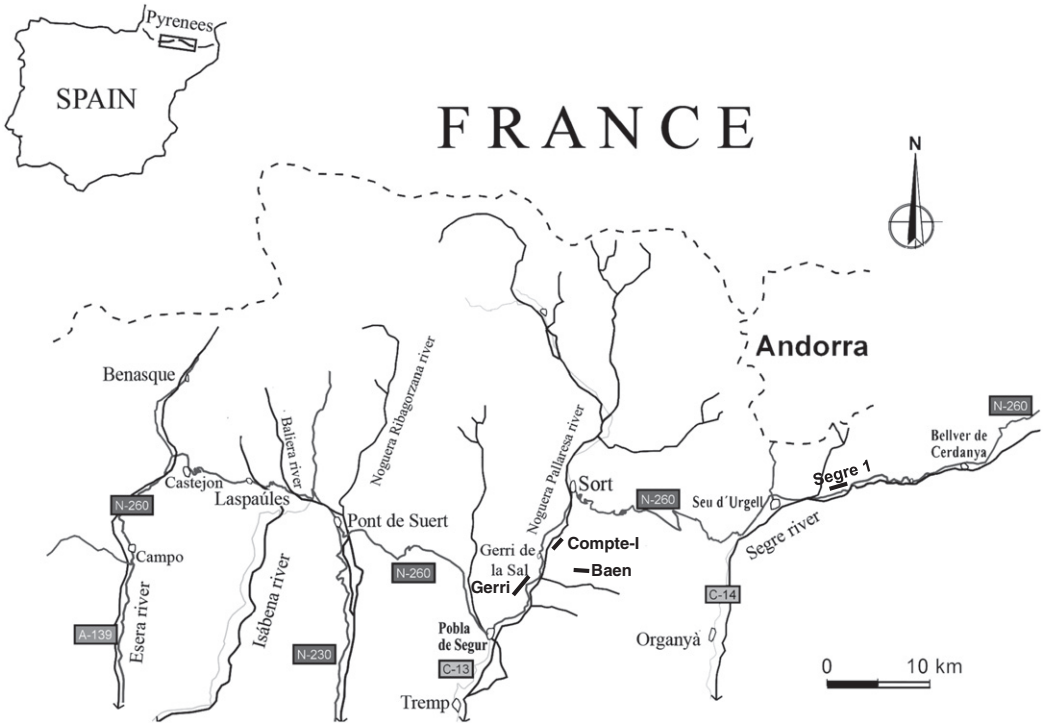

Fig. 1. Geographical setting of the Spanish Pyrenean sections. Gerri includes the two sections Gerri 1.1 and Gerri 1.2.