The Crozonaspis incerta Biozone (Middle Ordovician) in the Iberian Peninsula: shallow water sands, storms and particular biofacies correlation

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Abstract

The *Crozonaspis incerta* Biozone was first defined in Normandy (W France) by the vertical range of its eponymous trilobite, which occur associated with a particular assemblage of homalonotid trilobites of the genera *Eohomalonotus*, *Iberocoryphe*, *Kerfornella* and *Plaesiacomia*. It comprises a dozen species occurring exclusively in sandstones, being interpreted as representing a very shallow nearshore biofacies, the most proximal known in high-latitude Ordovician Gondwanan shelf. Given its environmental dependence, it is difficult to assess the biostratigraphic value of this association.

Unlike the scarce records in the Armorican Massif (Lower May and Mont de Besneville formations), this trilobite assemblage dominated by homalonotids, few representatives of *Crozonaspis* (*C. incerta, C. armata*) and a single *Neseuretus* species (*N. henkei*), is much more widespread in the Iberian Peninsula, as shown herein.

In a somewhat correlatable way with Normandy, the *C. incerta* Biozone reaches its maximum development in the southernmost part of the Central-Iberian Zone, coinciding with the shallowest part of the Iberian Gondwanan shelf. There, Dobrotivian (upper Darriwilian to lowermost Sandbian) strata are mainly represented by medium-grained sandstones bearing this homalonotid biofacies, but a similar assemblage is also recorded in a parallel belt dominated by siltstones and sandstones, following the gentle seaward slope of the Iberian shelf to the north and northeast (present-day coordinates). The record of *C. incerta* Biozone in this deeper area is limited to intercalations of sandstones or to lenticular coquinas evidencing short living conditions for homalonotid communities, removal by storms or transport by

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offshore currents. Certain widespread homalonotids, such as *Plaesiacomia* and *Kerfornella*, can also live in finer sediments. To the N and NE, there is the extensive muddy shelf that characterised the northern Central Iberian Zone, where coeval shales and siltstones are devoid of sandstone intercalations and these trilobites are unknown.

In Spain, the *C. incerta* Biozone has been recorded in El Caño and Botella formations of eastern Sierra Morena, Solana del Pino and Guadalmez synclines, the upper Elice-lowermost Torrico formations of the Cáceres and Santiago de Alcántara-Sierra de San Pedro synclines, and in the Iberian Cordillera (upper part of the San Marcos Formation and uppermost part of the Castillejo Formation), as well as in the Obejo-Valsequillo Domain (Belmez, Córdoba). In Portugal, *C. incerta* is known in the uppermost Cabril Formation of the Penha Garcia Syncline and, with doubt, in a correlatable unit from the Águeda inlier. Nevertheless, an homalonotid assemblage similar to that of the Botella Formation is also known in the uppermost Cabril Formation of the Amêndoa-Carvoeiro Syncline.

The trilobites recorded in Spain within *C. incerta* Biozone include *Eohomalonotus sdzuyi, E. brongniarti, E. vicaryi, Iberocoryphe verneuili, I. bonissenti, I.*? aff. *besnevillensis, Kerfornella brevicaudata, Plaesiacomia oehlerti, P. hesselinki, Neseuretus henkei, Crozonaspis incerta* and *C. armata*. Brachiopods are relatively common, and their representatives vary depending on the diachronic development of the sandy biofacies, from scarce occurrences of *Heterorthina morgatensis* in their earlier developments (e.g. El Caño Formation), to abundant *Heterorthina kerfornei* or *Tafilaltia valpyana* that characterize the younger records (e.g. Botella Formation). Other relatively frequent groups are rostroconchs and bivalve molluscs that also inhabit muddy environments, such as *Ribeiria pholadiformis*, *Cardiolaria beirensis* and *Hemiprionodonta lusitanica*, as well as bryozoans and disarticulated plates of pelmatozoan echinoderms. In Portugal, *C. incerta* only occurs with undetermined homalonotids, although *Tafilaltia* cf. *valpyana* and fragmentary bryozoans were reported from the homalonotid biofacies of the uppermost Cabril Formation.

Due to the environmental control of these species, biochronological markers to characterize this biozone are lacking. The age determination is relative, based on the dating of the units under- and overlying it: late Oretanian to early Dobrotivian fossiliferous shales and siltstones, and Berounian units, respectively. Here we present a direct attempt at dating this trilobite assemblage, through the first record of graptolites in the *C. incerta* Biozone, coming from SW of Alamillo (Ciudad Real), basal Botella Formation. This is represented by abundant specimens of *Oepikograptus bekkeri*, nicely preserved in sandstones and current-aligned. As this biserial form is highly characteristic of the early Sandbian *Nemagraptus gracilis* Biozone, their occurrence within *C. incerta* Biozone implies that corresponding trilobite biofacies, essentially developed in the late Darriwilian, also extends into the early Late Ordovician.
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