The Evae transgression: a major event?

Gisella M. Della Costa and Guillermo L. Albanesi

Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba,
Av. Vélez Sarsfield 299, X5000 JJC, Córdoba, Argentina

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Corresponding author:
Gisella M. Della Costa
gisebiodellacosta@gmail.com

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ABSTRACT

The most extensive sea-level event of the Early Ordovician is known as the Evae transgression. During the highstand of this event, the conodont index species *Oepikodus evae* reached its acme and often coincided with the peak in conodont generic diversity. The main objective of this study is to statistically evaluate the degree of similarity in conodont species composition between the Argentine Precordillera, Laurentia, Baltica, Kazakhstania, South China, and Australia at that time. Cluster analysis shows two main faunal groups moderately to poorly differentiated, indicating that some paleogeographic barriers may not have decreased during the Evae transgression. On the other hand, a paleolatitudinal control over the distribution of species is suspected, considering the occurrence of a higher number of species dwelling in mid-low latitudes than in mid-latitudes. This suggests that this event could have been of a lesser magnitude or duration than previously claimed.

Introduction

The Evae transgression is considered the most extensive of the Early Ordovician (Bagnoli 1994). This event was explicitly reported in some sections of Laurentia, Baltica, South China, and the Argentine Precordillera (Stouge and Bagnoli 1988; Barnes 2004; Wu et al. 2010a, 2010b; Mango and Albanesi 2021). The index species *Oepikodus evae* reached its acme during the highstand of that transgression (Bagnoli 1994). Moreover, the first peak of conodont generic diversity has been recorded in Baltica (Nielsen 2004; Männik and Viira 2012) and South China (Wu et al. 2010a, 2010b) at that time. During the highest sea-level rises, shelf expansion leads to open-water species colonizing these environments, which occasionally drove some shelf species to extinction (Fortey 1984; Lehnert et al. 2013). At the same time, the appearance of new species by adaptive radiation often coincides with major transgressive events (Bagnoli 1994; Nielsen 2004). Another faunal response is the more fluid exchange of species at a global scale because the paleogeographic barriers tend to decrease, resulting in a provincial breakdown (Fortey 1984; Albanesi and Bergström 2010). The main objective of this study is to statistically evaluate the degree of similarity in conodont species composition between the Argentine Precordillera, Laurentia, Baltica, Kazakhstania, South China, and Australia during the highstand of the Evae transgression.

Materials and methods

The highstand of the Evae transgression is defined here as the time interval when the conodont index species *Oepikodus evae* reached its acme, often coinciding with the peak in conodont generic diversity (Bagnoli 1994; Wu et al. 2010a, 2010b; Männik and Viira 2012; Mango and Albanesi 2021). Studies that do not fit this definition were excluded. This resulted in some plates, such as North China (e.g. An et al. 1983), Siberia (e.g., Sennikov et al. 2015) and intracratonic basins of Australia (e.g. Stewart and Nicoll 2003) not being represented in the analysis. A total of 35 studies from 28 sections worldwide were selected, located in the Argentine Precordillera, Newfoundland, Baltoscandia, South China, Kazakhstan, and Australia (Fig. 2A and references therein). The degree of similarity in conodont species composition was assessed by cluster analysis using the Jaccard index (Ji), which has a range from 0 (no similarity) to 1 (maximum similarity) (Jaccard 1912). Based on the similarity matrix generated, the degree of similiarity between the different paleocontinents is defined here as low or poor (Ji 0 to 0.49), intermediate or moderate (Ji 0.50 to 0.70) or high (Ji 0.71 to 1). The analysis was performed with PAST 4.10 software (Hammer

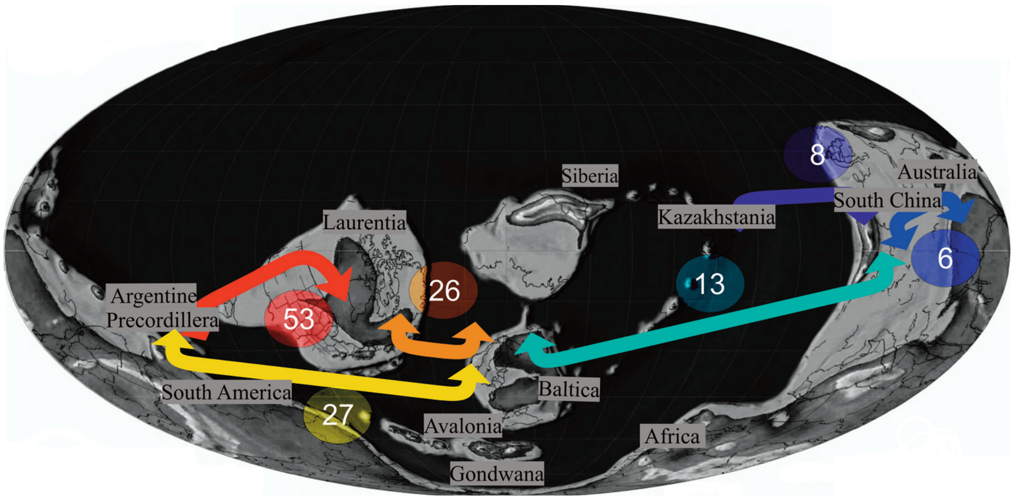

Fig. 1. Paleogeographic map showing the possible migration shortcut routes and the number of shared species between the Argentine Precordillera, Laurentia, Baltica, Kazakhstania, South China, and Australia during the Evae transgression (modified after Scotese 2014).

et al. 2001). Undetermined and redeposited conodont elements were excluded and some species were synonymized.

Results and discussion

Cluster analysis shows two main faunal groups moderately to poorly differentiated (Ji 0.22 to 0.50) during the Evae transgression (Fig. 2B). The first group includes Australia and Kazakhstania with a relatively low faunal similarity (Ji 0.22), which indicates a limited species interchange between these relatively nearby areas at that time. Based on the paleolatitudinal location of Australia and Kazakhstania (Fig. 1), we consider that the main barriers that might have restricted the species migration were temperature (convergence of cold-warm waters) and/or paleolatitudinal constraints. The lower number of species found in Australia and Kazakhstania (Fig. 2A) indicates unfavorable environmental conditions for the survival of various species during the Evae transgression. In addition, the presence of a few endemic species in Kazakhstania suggests a certain degree of isolation of this region during that sea-level rise. However, these results could be affected by sampling bias because Australia is represented only by the Lachlan Orogen section and Kazakhstania by the Akzhal suite and Barite quarry sections in the present stat-

A

Paleocontinents	Richness	Sections	Sources of information
Argentine Precordillera	74	Portezuelo Yanso, Niquivil, Los Gatos Creek, La Silla, Peña Sombría	Albanesi et al. 1998; Albanesi et al. 2006; Mango and Albanesi 2018, 2019, 2020; Authors' unpublished data
Laurentia	86	Deep Kill, Martin Point, St Pauls Inlet North, Marathon, Wilcox Pass, Profilstranda, South Mayo, N8 9252 (Raven Gill)	Landing 1976; Fåhraeus and Nowlan 1978; Johnston 1986; Stouge and Bagnoli 1988; Johnston and Barnes 1999; Izold 1993; Armstrong et al. 2001; Pyle and Barnes 2002; Pyle et al. 2003; Lehnert et al. 2013; Stouge et al. 2015
Baltica	30	Furuhäll, Horns Udde, Andersön A, Section A (Jämtland), Finngrundet core, Gymninge, Sjurberg, Orreholmen, Mäekalda, Saka	Bagnoli et al.1988; Bagnoli and Stouge 1997; Ahnesjö 1998; Löfgren 1978, 1985, 1993, 1994, 1996; Viira et al. 2001; Viira et al. 2006
Kazakhstania	20	Akzhal suite, Barite quarry	Tolmacheva 2014; Tolmacheva et al. 2021
South China	34	Huanghuachang, Liushuting	Wang et al. 2005, 2009; Wu et al. 2010a, 2010b; Li et al. 2010
Australia	8	Lachlan Orogen	Zhen et al. 2021

B

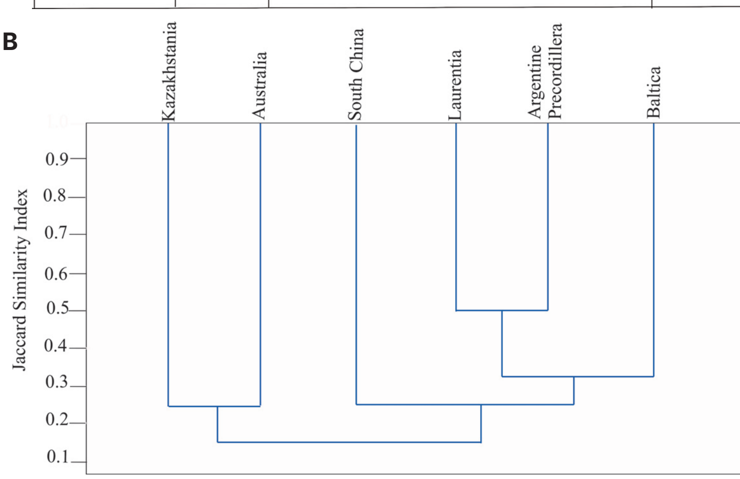

Fig. 2A – table of data sets used in this study; **2B** – dendrogram from the cluster analysis based on the Jaccard index showing the similarity in conodont species of the lower *Oepikodus evae* interval between the Argentine Precordillera, Laurentia, Baltica, Kazakhstania, South China, and Australia.

istical analysis (Fig. 2A). Moreover, these sections represent siliciclastic depositional environments, which are poorer for the preservation of conodonts than carbonate-dominated settings (Zhen et al. 2021).

The second group consists of two subgroups, one exclusively with South China, and another formed by Laurentia, the Argentine Precordillera and Baltica. South China shares a relatively low proportion of species with Laurentia (Ji 0.19) and the Argentine Precordillera (Ji 0.26), probably due to the existence of a paleolatitudinal control over the distribution of species during the Evae transgression. In addition, the land areas of Kazakhstania could have functioned as barriers to the dispersal of species from South China to other paleocontinents. A few species are shared exclusively between South China and Australia, showing some exchange between those nearby plates. Moreover, some species were reported exclusively in South China, supporting the idea of a certain degree of isolation of this plate at that time. Although South China is represented by two sections (Fig. 2A), only the Huanghuachang section was heavily sampled as a candidate section for the GSSP of the Dapingian Stage (e.g. Wang et al. 2009). Consequently, it can be assumed that the results are not significantly affected by sampling bias, and probably most of the species that occurred in South China at that time were recorded. Laurentia and the Argentine Precordillera share a higher proportion of species (Ji 0.50), probably due to their close paleogeographic proximity and similar paleolatitudinal position. This probably allowed a more significant exchange of species than with other paleocontinents (Fig. 1). Baltica has less faunal similarity with Laurentia (Ji 0.29) and the Argentine Precordillera (Ji 0.35), perhaps because its location at mid-high latitudes resulted in latitudinal and oceanic constraints, which limited the migration of species there. On the other hand, Laurentia and the Argentine Precordillera show the highest species richness (Fig. 2A), indicating that these areas were the most suitable for the survival of most species under the prevailing conditions. This suggests a latitudinal gradient, with a higher number of species dwelling in mid-low latitudes than in mid-latitudes. Although some degree of exchange between relatively close paleocontinents was identified, it would be less than expected for an event of major magnitude or duration (Fortey 1984). In addition, Kazakhstania, Australia and South China were somewhat isolated, indicating that many paleogeographic barriers may not have decreased during the Evae transgression (Albanesi and Bergström 2010), contrary to what would be expected for a greater transgression.

Conclusions

In the present study, a limited exchange of species between most of the paleocontinents was identified indicating that some barriers may not have been decreased at that time. On the other hand, a possible paleolatitudinal control over the distribution of species during the Evae transgression is suspected. This suggests that this event could have been of a lesser magnitude or duration than previously claimed. Nevertheless, these interpretations are based exclusively on the statistical distribution of species in selected sections from the Argentine Precordillera, Baltica, Laurentia, South China, Kazakhstania and Australia, which fit the definition of the Evae transgression considered here. Additionally, the siliciclastic depositional environments and low representation of some sections could have biased the results.

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