



General palaeontology, systematics and evolution (Micropalaeontology)

New insights into the paleobiogeography of the Early Ordovician graptolite fauna of northwestern Argentina

Nouveau regard sur la paléobiogéographie de la faune de graptolites de l'Ordovicien inférieur de l'Argentine nord-occidentale

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ABSTRACT

A multivariate analysis was used to determine the faunistic relationships of the northwestern Argentinean graptolite faunas of Floian age to faunas from Baltica, Avalonia, Laurentia and SW China. A statistical analysis at the species level of the five geographic regions for the Lower Floian was performed with the classic Jaccard's index. The resulting affinity dendrogram shows stronger relationships between Early Floian graptolite faunas of northwestern Argentina and those from Baltica, with less obvious similarities to Great Britain (Avalonia) faunas and only weak affinities to North American (Laurentia) and Chinese (SW China) graptolite faunas. The statistical analysis confirms the paleobiogeographic relationships previously observed in other areas of the Cordillera Oriental, and supports the hypothesis that during the Early Ordovician, northwestern Argentina was located at middle to high latitudes, corresponding to the Atlantic Faunal Realm of cold water graptolite biofacies. The studied graptolite material from the Quinilicán and Agua Chica sections is preserved in shales and siltstones interbedded with fine to medium-grained sandstones corresponding to the lower part of the Acoite Formation. The biostratigraphic implications of the associated graptolites are briefly discussed, and *Trichograptus dilaceratus* (Herrmann), *Acrograptus gracilis* (Törnquist), *Expansograptus latus* (T.S. Hall) and *Corymbograptus v-fractus tullbergi* (Monsen) are described from the Argentine Cordillera Oriental for the first time.

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R É S U M É

Une analyse multivariée a été utilisée pour déterminer les relations faunistiques de faunes de graptolites d'âge Floïen d'Argentine nord-occidentale avec des faunes de la Baltique de l'Avalonie, de la Laurentie et du Sud-Ouest de la Chine. Une analyse statistique au niveau de l'espèce de cinq régions du Floïen inférieur a été réalisée grâce à l'indice classique de Jaccard. Le dendrogramme d'affinité qui en résulte montre des relations étroites entre les faunes de graptolites du Floïen inférieur de l'Argentine nord-occidentale et celles de la Baltique, des similarités moins évidentes avec les faunes de Grande-Bretagne (Avalonie) et seulement de faibles affinités avec les faunes de graptolites d'Amérique du Nord (Laurentie) et de Chine (Sud-Ouest de la Chine). L'analyse statistique confirme les relations

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paléobiogéographiques précédemment observées dans d'autres régions de la Cordillère Orientale et était l'hypothèse selon laquelle, au cours de l'Ordovicien inférieur, l'Argentine nord-occidentale était située à de moyennes à hautes latitudes correspondant au domaine faunique atlantique à biofaciès de graptolites d'eau froide. Le matériel graptolitique étudié en provenance des coupes de Quinilicán et Aqua Chica a été conservé dans des schistes et siltites avec intercalations de grès à grain fin à moyen, correspondant à la partie inférieure de la Formation Acoite. Les implications biostratigraphiques des graptolites associés sont brièvement discutées et *Trichograptus dilaceratus* (Herrmann), *Acrograptus gracilis* (Törnquist), *Expansograptus latus* (T.S. Hall) et *Corymbograptus v-fractus tullbergi* (Monsen) sont décrites pour la première fois dans la Cordillère Orientale d'Argentine.

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1. Introduction

Graptolites are considered an important tool to establish the biostratigraphic framework and regional and worldwide correlations of Lower Paleozoic sedimentary successions of northwestern Argentina. Their faunal affinities also provide valuable information for the understanding of the paleogeographic relationships of the Argentinean Ordovician. During the last decade, most of the efforts have been focused to develop and refine the biostratigraphic framework, as well as to accurately compare and correlate Ordovician biozonation schemes based on various additional fossil groups like trilobites and paly-nomorphs (Brussa et al., 2008; Rubinstein et al., 2007; Waisfeld et al., 2006). In contrast, paleobiogeographic, phylogenetic and evolutionary aspects of the research of these biostratigraphic relevant taxa remain without a comparable development until now. Even though modern taxonomic revisions frequently apply statistical methodologies to quantify the relevant characters of graptolites, either isolated or preserved in relief, only recently biogeographically important new taxa were recognized and described from the Cordillera Oriental (Toro and Maletz, 2008), and the best preserved material was compared with type material of key species from other regions around the world (Toro and Maletz, 2007; Vento and Toro, 2009).

An exhaustive taxonomic re-evaluation based on the best preserved material of biostratigraphically and paleobiogeographically relevant species from the Lower Ordovician of northwestern Argentina is still lacking. This paper deals with the statistical treatment of the faunal affinities and the biostratigraphic analysis of the graptolite fauna of this region, which enables us to confirm its early Floian age. We also provide systematic descriptions of four paleobiogeographically important taxa, identified for the first time in Argentina.

The described material originates from the Quinilicán and Agua Chica sections, at the northern end of the Aguilar Range, in the Argentine Cordillera Oriental (Jujuy Province) (Fig. 1). This region represents the southern portion of the central Andean Basin, and according to recent studies it evolved as the forebulge depozone of the extended Ordovician foreland basin system in Northwest Argentina. Early Ordovician platform sediments of the Cordillera Oriental are represented by black and grey shales and siltstones interbedded with fine to medium-grained sandstones toward the top of the sequence of the

Santa Victoria Group (Upper Cambrian-Middle Ordovician), which include the Santa Rosita and Acoite formations. This succession was deposited on a low gradient ramp, under the influence of a large scale prograding deltaic system from the east and of an active volcanic arc complex to the west (Astini, 2003; Bahlburg and Furlong, 1996).

Numerous sections of an average thickness of approximately 600 m, representing the lower part of the Acoite Formation, are exposed in the northern end of the Aguilar Range (Fig. 1). These are of outstanding interest for research on Early Floian graptolites, because specific investigations of these faunas have not been made there for the past decade, while the taxonomic and biostratigraphic understanding of faunas from this interval has changed considerably, based on new data from Scandinavian successions (Maletz, 2005; Egenhoff and Maletz, 2007; Maletz and Ahlberg, 2011).

The graptolites of the studied area are usually preserved as carbonized films of periderm in grey shales and siltstones in the lower part of the Acoite Formation. They are commonly filled with pyrite in fine to medium-grained sandstones, which appear more frequently intercalated in the upper part of the unit. They may show considerable tectonic deformation and often are encased in a thin layer of chloritic pressure shadow minerals.

The outcome of this work is part of the PhD thesis of one of the authors (B.V.). It is expected that these records, along with other data coming from different areas of northwestern Argentina, will increase the database for the statistical treatment, which allows the quantification of taxonomic and phylogenetic relationships, and the clarification of evolutionary and paleoecological trends of Ordovician graptolites.

2. Regional biostratigraphy

A detailed biostratigraphic analysis exceeds the main scope of this paper, but is under study by Toro and Vento (in press). The new records of key species in the studied area are briefly commented upon and included in Fig. 2, as they allow more accurate identification of the age of the analyzed biostratigraphic interval.

The *Tetragraptus phyllograptoides* Biozone was defined in the Floian stratotype section of Mount Hunneberg, SW Sweden (Maletz et al., 1996) and identifies the base of the Floian at the FAD of *Tetragraptus approximatus* Nicholson and *T. phyllograptoides* Strandmark. The fauna

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