



Mississippian–Early Permian brachiopods from western Argentina: Tools for middle- to high-latitude correlation, paleobiogeographic and paleoclimatic reconstruction

Arturo César Taboada

Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)–Laboratorio de Investigaciones en Evolución y Biodiversidad (LIEB), Facultad de Ciencias Naturales, Sede Esquel, Universidad Nacional de la Patagonia “San Juan Bosco” (UNPSJB). Edificio de Aulas, RN259, km. 16,5, Esquel (U9200), Chubut, Argentina

ARTICLE INFO

Article history:

Received 19 October 2009

Received in revised form 30 June 2010

Accepted 9 July 2010

Available online 16 July 2010

Keywords:

Brachiopod faunas

Late Paleozoic

Western Argentina

Biostratigraphy

Paleobiogeography

Glaciations

ABSTRACT

Brachiopod faunas from western Argentina are reviewed to improve the current understanding of their biostratigraphic and paleobiogeographic value for intercontinental correlation and paleoclimatic reconstruction, especially for middle to high paleolatitudes. The oldest faunal assemblage, the late Tournaisian–early Viséan Malimanian fauna, indicates an incipient biogeographic segregation of southwestern South America from contemporaneous peri-Gondwana and northern hemisphere regions, likely due to the enhanced thermal gradient that predated the pronounced latest Viséan global cooling and the major latitudinal biotic differentiation on a global scale. Paleogeographical distribution of key brachiopod taxa provides evidence of faunal interchange along western Gondwana during late Early Carboniferous. The paleoclimate of the region by this time has been interpreted as temperate preglacial conditions, in a higher paleolatitudinal setting. Global cooling and strong differentiation between marine biota of circum-polar and paleoequatorial regions occurred after late Viséan. The Barrealian fauna (*Rugosochonetes-Bulahdelia* and *Levipustula* assemblages), represents the oldest faunal record in western Argentina of this major latitude-related biotic segregation linked with the onset of the mid-Carboniferous glaciation. The Barrealian fauna appeared during a major late Viséan–Serpukhovian glacial episode with short-lived glacial and interglacial stages. Climatic fluctuations were probably related to local faunal changes and marine biotic exchange between higher and middle paleolatitudes of southwestern and eastern Gondwana. Widespread postglacial deposits bearing Bashkirian faunas demonstrate the beginning of a progressive climatic amelioration trend until early Permian times, barely affected by short-lived colder paleoclimatic fluctuations. The incoming of the late Bashkirian–early Moscovian *Marginovatia-Maemia* fauna was linked to a climatic change in the region following the disappearance of glacial conditions in westernmost Argentina. Ocean currents from the north, that reached the region bringing boreal brachiopods, were warm enough since Bashkirian times to build a thermal barrier for the biotic interchange with peri-Gondwana regions under subpolar settings and a faunal disconnection was established. In addition, asymmetrical climatic record between western Argentina and regions still under strong glacial influence, such as Patagonia and eastern Australia, reflect the clockwise rotation of Gondwana and consequent migration of western Argentina to lower latitudes. After a preceding mainly regressive depositional interval, the marine incursion bearing the *Tivertonia-Streptorhynchus* fauna accompanied the most extensive transgression that covered western Argentina. It was probably linked with the beginning of a thalassocratic regime by the global major sea level rise of late Asselian–Sakmarian times. The *Tivertonia-Streptorhynchus* assemblage represents a middle paleolatitude temperate and mixed fauna, which migrated toward southern Gondwana regions, indicating a marine faunal connection during a climatic amelioration trend. The last marine incursion in western Argentina brought the *Costatumulus* fauna, linked to a brief interruption of the mostly temperate paleoclimatic conditions established since the Pennsylvanian. A short-lived minor glacial pulse associated with the *Costatumulus* fauna reflected local mitigated climatic fluctuations, by the paleolatitudinal gradient to circumpolar areas where a major glacial pulse occurred during Sakmarian–Artinskian times.

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1. Introduction

Upper Paleozoic faunas of Argentina include brachiopods of antitropical and bipolar paleogeographic allocation as key elements to characterize marine biotic events throughout the southwestern margin of Gondwana. Warm-water fossils such as fusulinids and

E-mail address: ataboada@unpata.edu.ar.

conodonts are almost absent in all Argentina regions, making difficult the precise correlation with the standard sections established in the northern paleotropics.

Brachiopod faunas from the Uspallata-Iglesia Basin in western Argentina are here reviewed to improve the current understanding of its biostratigraphic and paleobiogeographic value for paleoclimatic reconstruction, especially for middle to high paleolatitudes.

The Uspallata-Iglesia Basin of western Argentina and the Tepuel-Genoa Basin in Patagonia currently separated by 1300 km share related paleobiological events during the Carboniferous–Early Permian, but also exhibit significant differences in faunal composition. Its analysis highlights migration pathway developments between both regions. During the Pennsylvanian temporary temperature barriers were created, which allowed the appearance of reproductively isolated faunal communities. Through the Early Permian, there was a progressive recovery of migration pathways along the southwestern margin of Gondwana for the biotic interchange between western Argentina, Patagonia and other Gondwana regions. In western Argentina, strong paleoclimatic oscillations are reflected in the record of glacial-related horizons and interglacial intervals, but a general climatic amelioration trend was established after Bashkirian time, intermittently interrupted by a few minor glacial pulses.

2. General paleogeographical and stratigraphical setting

The paleogeographic framework currently recognized for southern South America includes intraplate basins located to the east of the region and arc-related and retroarc basins along the active margin of Gondwana, mostly in the western (Andean) region, which are separated by a large upland area (Limarino and Spalletti, 2006) (Fig. 1A). In Argentina, this ancient positive area has been defined as an elongate craton-shield of heterogeneous composition and probably without morphological continuity (Braccacini, 1960). During the Late Paleozoic in western Argentina, the so-called Protoprecordillera separated the western Uspallata-Iglesia Basin from the eastern Paganzo area (Salfity and Gorustovich, 1983; González Bonorino, 1991) (Fig. 1B, C), the former bearing the brachiopod faunas here analyzed.

Carboniferous sedimentation in western Argentina was preceded by the Late Devonian Precordilleran Orogeny (Furque, 1972), that produced a paleogeographic framework characterized by meridional ranges and basins. One of them was a narrow backarc area (50,000 km²) of deposition named Uspallata-Iglesia Basin (González, 1985), located between ~28°S–34°S, to the west of the Protoprecordillera (Amos and Rolleri, 1965) (currently comprising the Tontal, Invernada, Volcán and the austral part of the Punilla hills), and the Choiyoi magmatic arc to the west, near the Argentine–Chilean border. The Uspallata-Iglesia Basin has been traditionally assigned to two different basins/subbasins, the Río Blanco to the north and the Calingasta-Uspallata to the south (Amos, 1964), and the two oscillated allowing sea incursions from north and south and vice versa. On the other hand, the Protoprecordillera was likely a highland that mostly isolated the sea toward the more eastern Paganzo basin. In this scenario, various marine incursions occurred to the west of the Protoprecordillera and only twice surpassed and reached its eastern flank (Fig. 2).

The Uspallata-Iglesia Basin presents a complicated stratigraphy due in part to the strong tectonism that affected most of the Late Paleozoic deposits, now cropping out discontinuously. This circumstance has favoured a possible excessive number of lithostratigraphic units, some of them being poorly dated because of its nonexistent, insufficient or debatable fossil record. On the other hand, selected lithostratigraphic units by key paleobiota content and paleoclimatic evidence are here discussed to highlight temporal and spatial distribution of different faunal assemblages, as well as the

glacial pulses recorded in western Argentina, Patagonia and eastern Australia (Fig. 3).

3. The Malimanian fauna

The Malimanian fauna (González, 1993) (= Major Faunal Group A of González and Taboada, 1988), also known as the *Protopanites scalabrinii-Azurduya chavelensis* (Amos) faunal assemblage (Sabattini et al., 2001), has been described and/or illustrated from correlative sections of the Malimán, Punilla and Agua de Lucho formations (see Taboada and Shi, 2009 for full references). Other reports of the Malimanian fauna include a single goniatitid and abundant bivalves, among few other invertebrate groups (see Césari et al., 2007). In addition, the Zorritas Formation from northern Chile shares common species and genera with the Malimanian fauna, such as the brachiopods *Azurduya chavelensis* (Amos) and possibly *Yagonia* (Fig. 4), together with the gastropod *Bellerophon*, the conularid *Paraconularia* and the bivalve “*Posidoniella*” (now *Malimianina* of Waterhouse, 2001) (González, 1994; Isaacson and Dutro, 1999; Sabattini et al. 2001; Cisterna and Isaacson, 2003; Taboada and Shi, 2009).

The age of the biozone is currently regarded to be early Carboniferous, not older than late Tournaisian by goniatitids and brachiopods (Antelo, 1969; Taboada and Shi, 2009) and probably as young as early Viséan by macro- and microflora associations intercalated with beds bearing the Malimanian invertebrate fauna (Césari and Gutiérrez, 2000; Amenabar et al., 2006).

3.1. Paleobiogeographical considerations

The Malimanian fauna evidences the first Carboniferous marine incursion in western Argentina (Fig. 2A), by a gulf restricted to the northernmost part of the Uspallata-Iglesia Basin (González, 1994) likely connected with the Panthalassic Ocean through northern Chile (Isaacson et al., 1985; Dutro and Isaacson, 1991).

The Malimanian fauna and other slightly younger Gondwanan assemblages are generally low diversity associations lacking warm-water fossils. The fauna would thus indicate an incipient biogeographical segregation of the western margin of Gondwana (i.e., southwestern South America) from contemporaneous peri-Gondwana and Northern Hemisphere regions. The onset of this provincialism as demonstrated mainly by the low diversity brachiopods of the Malimanian fauna, is likely due to the enhanced thermal gradient (Dutro and Isaacson, 1991) that predated the pronounced latest Viséan global cooling and the major latitudinal biotic differentiation on a global scale (Taboada and Shi, 2009). In this context, the paleogeographical distribution of the Anopliidae *Yagonia* (late Tournaisian–late Viséan) has been suggested as evidence of a possible “south to north” faunal interchange that became established along western Gondwana during late Early Carboniferous. *Yagonia* appears to have expanded its range from southwestern South America (northwestern Argentina/northern Chile) reaching the remnant Rheic Ocean to the north of northwestern Gondwana and further to the northeast into the epicontinental Appalachian seaway (Taboada and Shi, 2009). The Austropanthalassic–Rheic interchange corridor between southwestern South America and the remnant Rheic Ocean was postulated (Taboada and Shi, 2009) to explain the presence of *Yagonia* in Mexico (Sour Tovar and Martínez Chacón, 2004) and central-eastern U.S.A (Carter, 1990) (Fig. 5).

3.2. Paleoclimatic considerations

The paleoclimate of southwestern South America at this time has been interpreted as temperate and humid preglacial conditions (paleoclimatic phase I of López Gamundi et al., 1992), although sporadic colder episodes apparently also occurred, as evidenced from

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