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Revision of Valanginian Steinmanellinae bivalves from the Neuquén basin, West-central Argentina, and their biostratigraphic implications

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ABSTRACT

We present a new species of *Steinmanella* Crickmay from the Valanginian of the Neuquén Basin, west-central Argentina, and at the same time update a Valanginian–earliest Barremian bivalve zonation which is integrated into the local, Chilean and European standard ammonoid zonations. *Steinmanella caicayensis* sp. nov. presents a moderately inflated shell, a subtriangular outline, well-developed carinae and a straight to moderately convex anterior margin. *Steinmanella* is very abundant in the Tithonian–Barremian interval in the basin and thus provides an ideal opportunity to perform detailed taxonomic and stratigraphic studies; a former zonation based on these trigonioids is here revised and expanded with a thorough revision of Valanginian occurrences based on new material. Two new zones are proposed, namely the *S. quintucoensis* and *S. caicayensis* zones, encompassing Valanginian times. The proposed bivalve zonation encompassing the Valanginian–earliest Barremian time interval can be useful in correlating with other southwestern Gondwanan regions, such as Perú, Chile, South Africa, Tanzania, and India, where *Steinmanella* has been recorded.

1. Introduction

The Valanginian units of the Neuquén Basin in west-central Argentina have yielded abundant trigonioid faunas since the pioneering studies on the Early Cretaceous stratigraphy of the basin at the close of the nineteenth century. Trigonioids were among the first fossils collected by Wilhem Bodenbender between 1887 and 1888, which were later described by Behrendsen (1892). In fact, trigonioids are one of the most conspicuous bivalve groups of the Lower Cretaceous marine successions of the Andean basins, and they have been frequently collected and studied since then (e.g., Behrendsen, 1892; Burckhardt, 1900, 1903; Camacho and Olivero, 1985; Lambert, 1944; Leanza and Garate Zubillaga, 1987; Leanza, 1993, 1998; Lazo, 2003; Levy de Caminos, 1969; Luci and Lazo, 2012; Weaver, 1931).

In particular, *Steinmanella* Crickmay (Myophorellidae, Steinmanellinae) is one of the most abundant and diverse trigonioid genera in the Tithonian–early Barremian interval in the basin. The genus is characterized by a robust quadrate to broadly triangular shell outline with a flank ornamented with oblique ribs composed of tubercles that make it easy to identify in the field. It has an almost uninterrupted record in the basin and has been found in different lithostratigraphic units within the Mendoza Group and in a variety of sedimentary facies, including shales, coquinas, carbonates, and sandstones. Many *Steinmanella* species have been erected and described throughout the twentieth century, but unfortunately most of them have not been accurately positioned stratigraphically and thus their temporal ranges and biostratigraphic significance remain unknown, along with unresolved phylogenetic relationships among them. In addition, many of these species are based on a limited number of specimens and intraspecific variation and ontogenetic change have not been taken into account. The genus has also been recorded from several localities of southwestern Gondawana, such as Perú, Chile, South Africa, Tanzania, and India, but few modern studies have been published so far.

A total of six species of *Steinmanella* from the Lower Cretaceous of the Neuquén Basin have been recently revised on the basis of new material collected under detailed stratigraphic control by Lazo (2003) and Luci and Lazo (2012). These species, are, in alphabetic order: *S. curacoensis* (Weaver, 1931), *S. pehuenmapuensis* Leanza, 1998, *S. quintucoensis* (Weaver, 1931), *S. subquadrata* Luci and Lazo (2012), *S. transitoria* (Steinmann, 1881) and *S. vacaensis* (Weaver, 1931). Their stratigraphic ranges is also discussed in the present paper. A seventh species, *S. caicayensis* sp. nov., is here

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reported for the first time. There are also records of five additional *Steinmanella* species in the basin, most of them probably of Tithonian–Berriasian age, that are poorly known given that they were erected on the basis of very few specimens with little stratigraphic control. These species are: *S. erycina* (Lambert, 1944), *S. haupti* (Lambert, 1944), *S. neuquensis* (Burckhardt, 1903), *S. splendida* (Leanza, 1941) and *S. steinmanni* (Philippi, 1899). Finally, the species *S. raimondii* (Lisson, 1930) was considered invalid by Lazo (2003).

Comprehensive revision of *Steinmanella* in Argentina, including taxonomy and biostratigraphy, has been carried out since 2003 as part of a long-term project on Early Cretaceous benthic assemblages of the Neuquén Basin, and the main results have been published in Lazo (2003), Lazo et al. (2009), and Luci and Lazo (2012). In particular, it has been shown that, although they display less temporal resolution than ammonoids, the genus is very useful in biostratigraphy and a number of zones have been designated (see Lazo et al., 2009). But, the early Valanginian record has remained poorly understood and is the subject of this study.

Therefore, the objectives of the present contribution are: 1) to revise the Valanginian records of *Steinmanella* at the species level in the northern and central parts of the Neuquén Basin, based on newly collected material; 2) to correlate *Steinmanella*-bearing beds with the associated local ammonoid fauna to establish accurate stratigraphic ranges for each studied species; and 3) to propose an updated Valanginian–earliest Barremian bivalve zonation integrated with local and European standard ammonoid zonations.

2. Geological setting

The Neuquén Basin was a back-arc depocentre developed during Late Jurassic–Early Cretaceous times, located near the Argentine–Chilean boundary along the Andes, between 32°-40° SL. Alternating marine and continental deposits accumulated in the basin due to periodic transgressions of the Pacific Ocean; a broadly triangular epeiric sea embayment was formed during times of high relative sea level. In the Kimmeridgian to Barremian interval, the Mendoza Group was deposited and encompasses, from base to top, the Tordillo, Vaca Muerta, Mulichinco and Agrio formations (Leanza and Hugo, 2005).

The Agrio Formation was defined by Weaver (1931) in the Río Agrio section within the Neuquén Embayment. In the type area, the section reaches more than 1000 m in thickness and can be subdivided into three readily distinguishable members. The lower Pilmatué Member is mainly composed of shales and mudstones interbedded with thin layers of packstones and wackestones, and the depositional setting has been interpreted to represent a shallow-marine ramp with storm influence (Spalletti et al., 2011). The middle Avilé Member, a thin continental unit, is represented by yellowish-brown, cross-bedded sandstones of eolian and fluvial origin, representing a second-order sea-level fall. The upper Agua de la Mula Member is largely composed of shales and mudstones in the lower part and gray calcareous shales interbedded with sandy limestones and sandstones in the upper part, and represents a new marine invasion of the basin (see Leanza and Hugo, 2005; Spalletti et al., 2011). The unit has a rich and abundant fossil record, first described in detail by Weaver (1931), composed mainly of invertebrates (bivalves, gastropods, nautiloids, ammonites, corals, crustaceans, echinoderms and serpulids), diverse trace-fossil assemblages, and scarce vertebrate remains (ichthyosaurs, plesiosaurs and pycnodontid fishes; see Lazo et al., 2005). Undoubtedly, the Agrio Formation corresponds to one of the most complete marine faunal successions spanning the early Valanginian to earliest Barremian (Lower Cretaceous) of the Southern Hemisphere. This age designation is based on an integrated biostratigraphy calibrated with a U–Pb zircon age (see Aguirre-Urreta et al., 2008).

Integrated studies on ammonoids, nannoplankton, and palynomorphs from the Agrio Formation have provided an excellent biostratigraphy for the unit and allowed better-constrained correlation to the European standard and to the Chilean Chañarcillo Basin zonations (see Aguirre-Urreta et al., 2007; Lazo et al., 2009; Aguirre-Urreta and Rawson, 2012). In this paper, we revise a previous late Valanginian-earliest Barremian bivalve zonation from the Neuquén Basin and propose a new integrated scheme involving both bivalves and ammonoids (Fig. 1). In particular we focus on the basal beds of the Pilmatué Member of the Agrio Formation, which encompasses the following ammonoid zones (from oldest to youngest): *Olcostephanus (O.) atherstoni*, *Karakaschiceras attenuatus*, *Viluceras permolestus* and *Pseudofavrella angulatiformis* subzones as described in Aguirre-Urreta and Rawson (1999, 2010) and Aguirre-Urreta et al. (2007). It is important to note that there is no agreement regarding the boundaries between the Agrio Formation and the underlying Mulichinco Formation, since some authors have considered that the *K. attenuatus*-bearing beds are the upper part of the latter whereas others have placed those beds as the base of the Agrio Formation (see Schwarz and Howell, 2005; Schwarz et al., 2011). The latter position is followed here. A brief description of the studied localities is given in order to more thoroughly describe the units, facies and age.

3. Fossil localities and methods

The revision of *Steinmanella*'s Valanginian records from the Neuquén Basin has been based on several fieldwork seasons. Arroyo Truquicó, Cerro Caicayén and Pichaihue, located in northern Neuquén, were selected due to records of abundant *Steinmanella*-bearing beds and easy access (Fig. 2). In the field, bed-by-bed sections of the basal beds of the Pilmatué Member of the Agrio Formation have been described with special focus on the Valanginian interval; collection of *Steinmanella* specimens was also done bed-by-bed with careful demarcation of ammonoid occurrences (Fig. 3). We followed the ammonoid zonation and ages proposed by Aguirre-Urreta and Rawson (1999, 2010) and Aguirre-Urreta et al. (2007). This zonation was very useful for lateral correlation among localities and for establishing the stratigraphic ranges of the studied *Steinmanella* species.

A number of additional Valanginian fossil localities were visited to collect material. At these sites, we only checked the basal beds of the Pilmatué Member (see Section 2) for Valanginian *Steinmanella* specimens and associated ammonoids. These localities include: Loma Tilhué, Cerro Negro and Cerro Mesa (see Sections 3.1–3.6).

3.1. Cerro Caicayén (37°26′30″S, 70°24′18″W)

The studied outcrops of the Agrio Formation are exposed on the right bank of the Rahueco Creek, just in front of Puesto Contreras, in the northern flank of Cerro Las Cortaderas. It is about 7 km east of Cerro Caicayén, the highest peak nearby, and 13 km southwest of Chos Malal. Access is from State Road 6 off National Road 40 towards Estancia Rahueco by taking an unpaved road for about 4 km towards the southwest (Fig. 2).

The basal beds of the Pilmatué Member are almost vertical but they can be easily followed and many *Steinmanella* specimens and associated ammonoids were collected. The type material of *S. caicayensis* sp. nov. was collected here. A section of the lower part of the Pilmatué Member was revised starting from the base that overlays the Mulichinco Formation sandstones on the basis of a section published by Aguirre-Urreta and Rawson (1999, fig. 3). The section encompasses the *Olcostephanus atherstoni, Karakaschiceras attenuatus*, *Viluceras permolestus* and the base of the *Pseudofavrella angulatiformis* subzones. The succession is composed mainly of