Late Cambrian – Tremadocian faunas and events from Angosto del Moreno Section, Eastern Cordillera, Argentina

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Key words: Faunas. Events. Late Cambrian – Tremadocian. Eastern Cordillera. Argentina.

Introduction

The Santa Victoria Group (SVG, late Upper Cambrian – Caradocian) comprises pre–Ashgillian Ordovician deposits of the Argentinean Eastern Cordillera. The most significant section of the SVG in the western flank of the Eastern Cordillera is located in the Angosto del Moreno area (Figure 1a, b). At this locality, the SVG unconformably overlies the Mesón Group (Cambrian *s.l.*), and unconformably underlies Cretaceous rocks (Yacoraite Formation). Upper Cambrian to lower Lower Ordovician units are separated from upper Lower to Middle Ordovician units (Parcha and Sepulturas formations) by the Tumbaya unconformity (Figure 2). The Angosto del Moreno Section of the SVG is exceptional in terms of the quality of exposures, continuity of deposits, richness of fossils, and accessibility. Diverse aspects concerning the Ordovician geology of this study area have been discussed by Moya *et al*. (1994, 1998), Moya and Albanesi (2000), Moya and Monteros (2000), Malanca and Brandán (2000), and Gómez Martínez *et al*. (2002). Previous data and recent paleontological collections enable a preliminary biostratigraphic scheme (Figure 2) for the Upper Cambrian to Tremadocian units of the SVG. A synthesis of the sequence stratigraphy and depositional environments of these units is given by Buatois *et al*. (this volume).

Late Cambrian – Tremadocian faunas and tectono–eustatic events

Five well–differentiated faunal associations were recognized in Upper Cambrian – Tremadocian deposits of the Angosto del Moreno. These associations define five stratigraphic intervals, which correspond to transgressive–regressive cycles bounded by sequence stratigraphic boundaries. These events and stratigraphic intervals are also documented in other areas of the Eastern Cordillera (Moya *et al.,* this volume). We consider that the events identified can be correlated quite accurately with tectono–eustatic fluctuations recorded worldwide for the Late Cambrian – Tremadocian: *Lange Ranch Eustatic Event* (LREE; Miller, 1984), *Acerocare Regressive Event* (ARE; Erdtmann, 1986) including two episodes (ARE1–ARE2, Cooper and Nowlan, 1999), and *Black Mountain Eustatic Event* (BMEE; Miller, 1984). A regional regressive event succeeding the BMEE is recognized in the Argentine Eastern Cordillera. This event, the *Kainella Regressive Event* (KRE; Moya *et al.,* this volume), would correspond, though still not verified, with the *Peltocare Regressive Event* (PRE; Erdtmann, 1986).

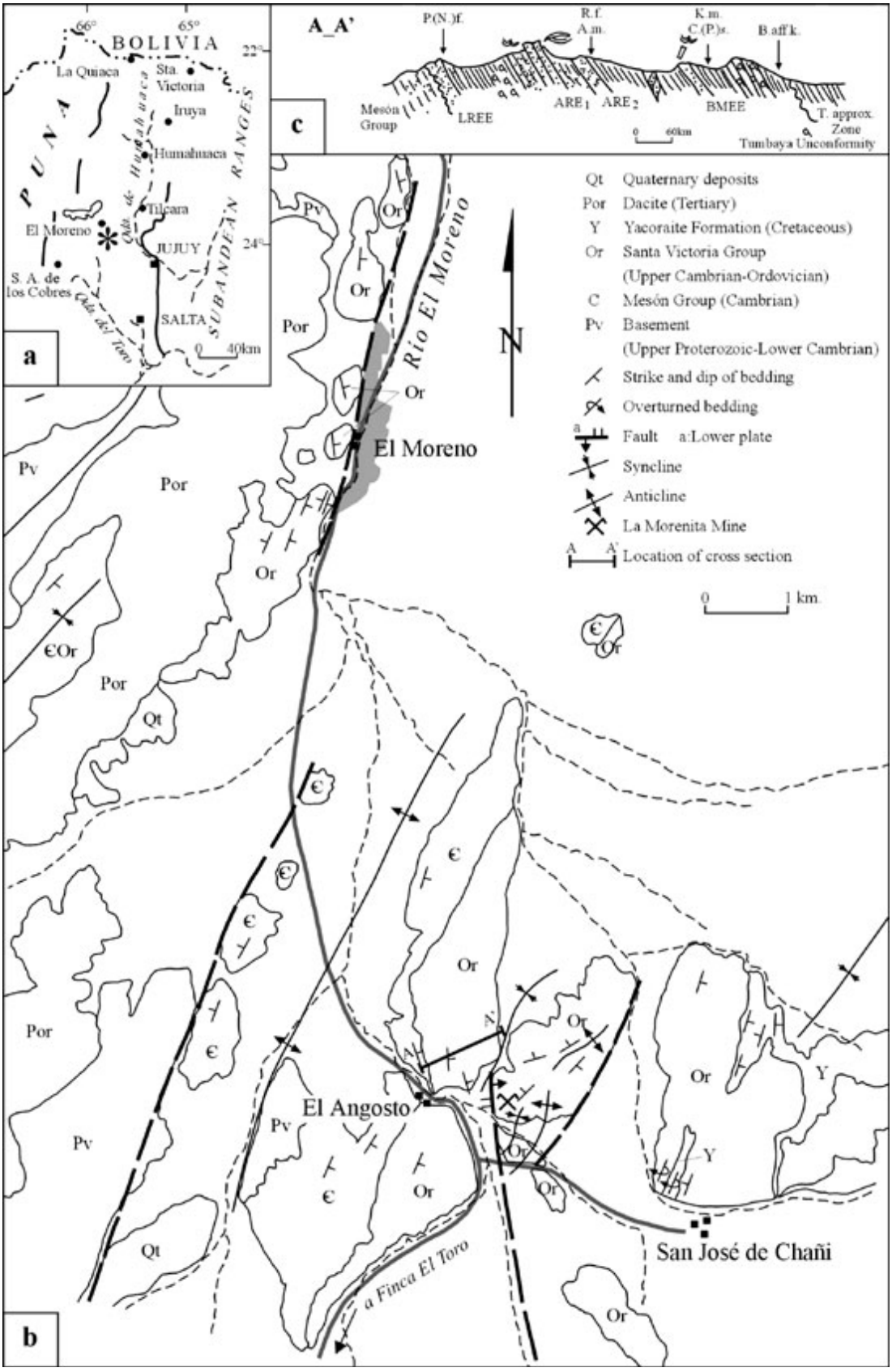

Figure 1. A. Location map. **B.** Geologic map of Angosto del Moreno area. **C.** Profile of the Upper Cambrian –Tremadocian deposits.

First Interval (LREE–ARE1). This interval embraces units 1 and 2 of Buatois *et al.* (this volume), and the lower interval of unit 3. The lowermost fossil records of the Angosto del Moreno Section, which correspond to *Parabolina (Neoparabolina) frequens* (Barrande), occur in the upper part of unit 1. The trilobite fauna from these strata is monospecific and it also occurs in shales of the lower third of unit 2, in coincidence with a

maximum flooding event. The shelly fauna increases notably within the highstand systems tract in middle and upper terms of the unit. Sandstone and coquina beds that characterize this part of the sequence contain *P (N.) frequens* together with *Parabolinella argentinensis* Kobayashi, *Angelina hyeronimi* (Kayser), *Angelina* cf. *A. hyeronimi, Leiostegium douglasi* Harrington, *Beltella ulrichi* (Kayser), *Plicatolina scalpta* Harrington and Leanza, *Micragnostus vilonii* Harrington and Leanza, *Micragnostus hoeki* Kobayashi, *Micragnostus* aff. *M. tilcuyensis* (Kayser) and *Ciceragnostus iruyensis* (Kayser), some of which range up to unit 4. One of the younger coquinas yielded conodonts of the *Hirsutodontus hirsutus* Subzone (*Cordylodus proavus* Zone), indicating a late Cambrian age. The subzone is represented by *Cordylodus proavus* Müller, *Cordylodus* cf. *proavus, Cordylodus primitivus* Bagnoli *et al., Cordylodus andresi* Viira *et al., Eoconodontus notchpeakensis* (Miller), *Hirsutodontus hirsutus* Miller, *Proconodontus muelleri* Miller, *Furnishina* sp., and *Prooneotodus* sp. This interval is capped by a shallowing–upwards sandstone succession (lower part of unit 3). Only trace fossils were found in this interval.

Second Interval (ARE1–ARE2). This interval comprises the middle and upper parts of unit 3. It is characterized by storm–dominated upper offshore to upper shoreface deposits. A sequence boundary, regarded as co–planar surface or amalgamated flooding surface/sequence boundary, is present at the base of this second interval (Buatois *et al.,* this volume). The transgressive systems tract is characterized by a fining–upward succession containing abundant trace fossils, which culminates in maximum flooding upper offshore deposits with complete specimens of *P. (N.) frequens.* This species is associated with *Parabolinella coelatifrons* Harrington and Leanza and the first records of shumardiids and pelturids, as well as, *Conophrys erquensis* (Kobayashi) and *Leptoplastides marianus* (Hoek). Nevertheless, *Jujuyaspis keideli* Kobayashi was not recorded, as it occurs in other areas of the basin (Moya *et al.,* this volume). The highstand systems tract is represented mostly by shoreface sandstones and coquinas. Neither conodonts nor graptolites were found in these strata. This interval may include the Cambrian–Ordovician boundary, because it is developed between the *Hirsutodontus hirsutus* Subzone and the *Anisograptus matanensis* Zone.

Third Interval (ARE2–BMEE). The lower part of unit 4, containing the transitional trilobite association between the *P. (N.) frequens* and *Kainella meridionalis* Zones that includes olenids and agnostoids as dominant forms, corresponds to this interval. The base of this interval is a sequence boundary represented by co–planar surface (ARE2). The transgressive systems tract, represented by proximal to distal outer shelf deposits, starts with the appearance of *Anisograptus matanensis* Ruedemann together with a low diversity benthic trilobite assemblage that includes *Saltaspis* sp. as the most common taxon. This species is associated with *Pseudokainella* sp., *Asaphellus* sp., cf. *Plicatolina* sp., *Hapalopleura acantha* Malanca, *Leiagnostus turgidulus* Harrington and Leanza, *Pseudorhaptagnostus (Machairagnostus)* sp., *Gymnagnostus* sp. and the last records of *P. (N.) frequens..* The maximum flooding coincides with an increase in the record of *A. matanensis*, which is accompanied by subspecies of *Rhabdinopora flabelliformis* (Eichwald) and a rich trilobite fauna. This fauna is characterized by the trilobites species of the Interval II has persisted yet, and the first appearance of orometopids, ceratopygids, richardsonellids, phacopids, and new species of shumardiids, as well as, *Onychopyge branisi* Suárez Soruco, *Skljarella* sp. cf. *S. notatifrons* (Harrington and Leanza), *Pseudokainella conica* (Kobayashi), *Apatokephalus exiguus* Harrington and Leanza, *Rossaspis rossi* (Harrington and Leanza), *Conophrys sulcatus* Malanca, *Angelina kayseri* Harrington and Leanza, *Geragnostus nesossi* Harrington and Leanza and *Pseudorhaptagnostus (Machairagnostus) tmetus* (Harrington and Leanza). The evolution of the sequence presents a short–duration progradating pulse. These deposits correspond to distal deltaic facies, which are covered by laminated mudstones. These levels are in turn overlain by wackes and calcareous coquinas. The interval culminates with sub– and intertidal deposits, represented by sandstones and bioturbated mudstones. The sequence boundary at the base of the third interval represents a hiatus, which may include the Cambrian–Ordovician boundary. If this is the case, the lowermost Tremadocian graptolite zones could be absent, reflecting a hiatus due to amalgamation between lowstand erosión and subsequent transgression.

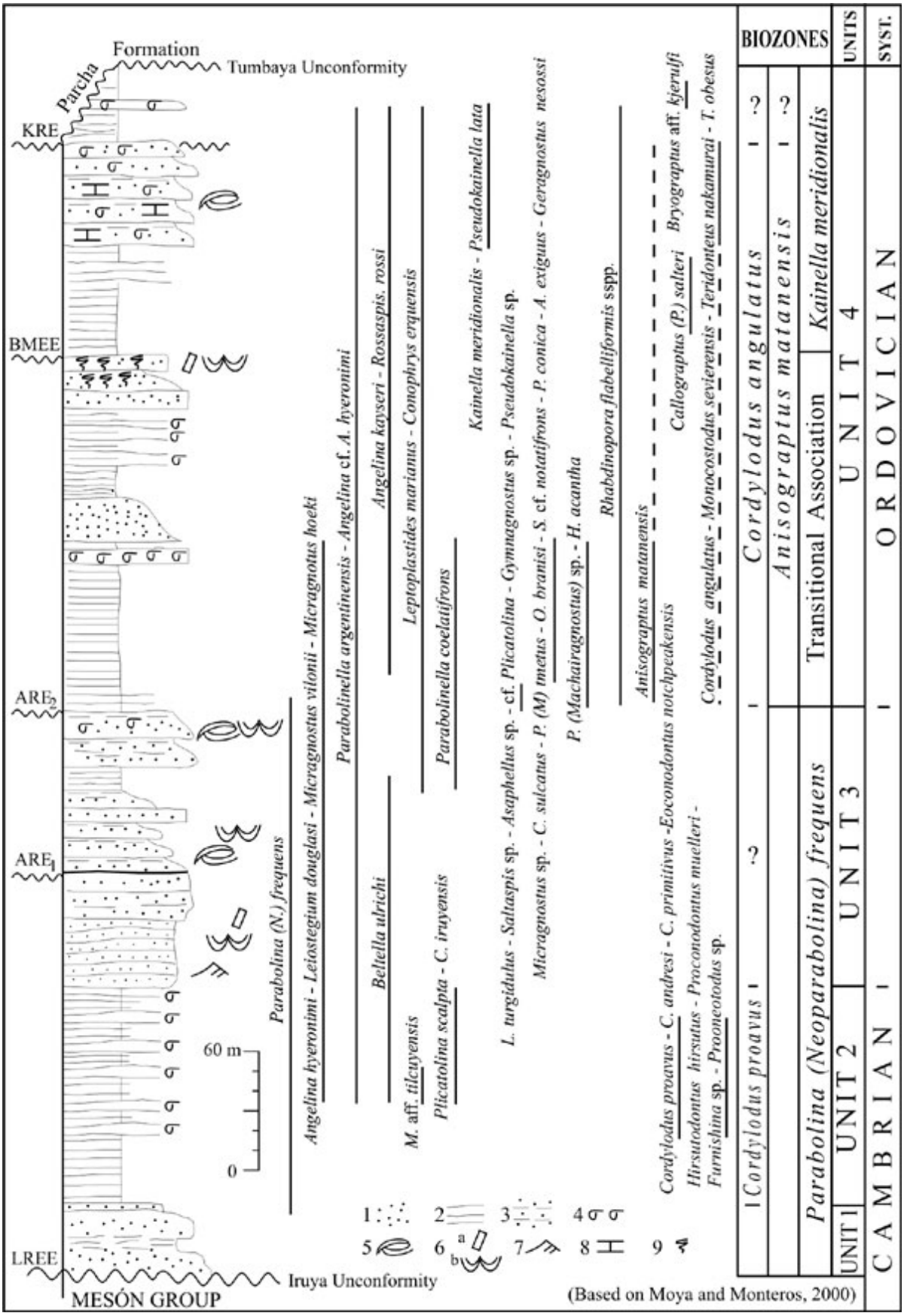

Figure 2. Stratigraphic column of the Upper Cambrian–Tremadocian deposits in the Angosto del Moreno area showing ranges of trilobite, graptolite, and conodont species. Legend: 1) Sandstone. 2) Shale. 3) Shale and sandstone. 4) Coquina. 5) Storm succession. 6) 6a, *Skolithos* ichnofacies; 6b, *Cruziana* ichnofacies 7) Ripples. 8) Calcareous sandstone.

Fourth Interval (BMEE–KRE). A rapid transgression is detected in another outcrop that occurs further south

in the same area. These deposits consist of laminated mudstones and scarce fine–grained sandstone beds. The maximum flooding coincides with the first record of *Callograptus (Pseudocallograptus) salteri* Hall associated with *A. matanensis* and *R. flabelliformis* ssp. First appearance of typical richardsonellids of the *K. meridionalis* Zone, *Kainella meridionalis* Kobayashi and *Pseudokainella lata* (Kobayashi), occurs at the beginning of the highstand systems tract. This succession is represented by siltstone deposits interbedded with sandstone and coquina layers, which become more common upwards, recording progressive shallowing. The coquinas yielded conodonts of the *Cordylodus angulatus* Zone (upper lower Tremadocian) that represents a low–diversity assemblage comprising the eponymous species, *Monocostodus sevierensis* Miller, *Teridontus nakamurai* (Nogami), and *T. obesus* Ji and Barnes.

Fifth Interval (KRE – Tumbaya Unconformity). Sandstones and coquinas that occur at the top of the Fourth Interval are covered by a fining–upward succession of parallel laminated mudstones, where the first appearance of *Bryograptus* sp. is recorded. This interval is barely represented in the El Moreno area Section due to the erosive Tumbaya Unconformity.

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Received: February 15, 2003

Accepted: June 15, 2003