

Exceptionally preserved fossil flora of the Río Leona Formation in Sierra Baguales, Magallanes, Chile: insights into the early Neogene Patagonian ecosystems.

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INTRODUCTION

Austral continental deposition during the Paleogene/Neogene transition includes sequences extensively exposed in southwestern Patagonia. One of these is the Río Leona Formation, a fluvial succession defined at Lago Argentino and the surrounding Río Leona Valley in Argentina (Marensi *et al.*, 2005). A remarkable attribute of this formation is the abundance of paleobotanical remains, mostly fossilized woods (Pujana, 2008). In Magallanes, a homologous unit is the El Salto Formation, a sandstone-dominated sequence with outcrops in the Brunswick Peninsula. Recently, Bostelmann *et al.* (in press), recognized the occurrence of the Río Leona Formation in Sierra Baguales (Fig. 1), northwestern Última Esperanza, in strata previously assigned to the imperfectly defined “Las Flores” Formation (Torres *et al.*, 2009; Ugalde *et al.*, this symposium). Fossils collected by our team in the Río Leona Formation include hundreds of exceptionally well preserved paleobotanical remains, with superb leaf impressions, inflorescences, thorns, fossil trunks and woods. The detailed study of these materials facilitates the reconstruction of the past continental ecosystem, of which a brief account is presented here.

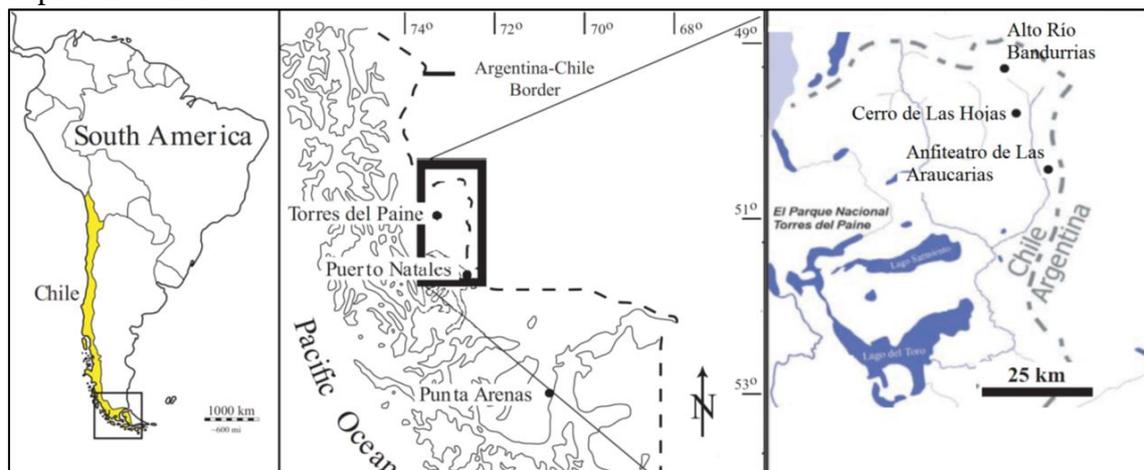


Figure 1: Study area with localities mentioned in the text (modified from Fildani *et al.*, 2007).

MATERIALS AND METHODS

The study site is situated in the northeastern extreme of the Última Esperanza Province, where Cenozoic stratigraphic sequences form the western exposures of the

foreland basin, as part of the fold-and-thrust belt (Fig. 1). Fossil collection and stratigraphic studies were conducted from 2008 to 2013 at three exposures of the Río Leona Formation: 1) Alto Río Bandurrias, 2) Cerro de Las Hojas, both located in the northern part of the Sierra Baguales; and 3) Anfiteatro de Las Araucarias, in the southern portion near the Las Flores Cattle Station (Fig. 1). Taxonomic identification of the leaf impressions was done according to their internal anatomy and following recent systematic reviews (Panti, 2010). We selected well-preserved specimens in which complete anatomical features could be observed, including limbos, margins, teeth, secondary and tertiary veins. All specimens were recorded in an information database, as well as photographed and sketched. Fossil morphotypes were contrasted with related modern species, and climatic tolerances were extrapolated from recent taxa, following the Nearest Living Relative Analysis methodology of Spicer (1990). Modern analogue specimens were selected from the Herbarium of Botany of the Faculty of Agricultural Sciences, University of Chile.

RESULTS

At Sierra Baguales, the Río Leona Formation lies unconformably on the marine Middle to Late Eocene Man Aike Formation, while its top grades concordantly into the marine succession of the Early Miocene Estancia 25 de Mayo Formation (Bostelmann *et al.*, in press). The most complete section recorded is at Anfiteatro de Las Araucarias site, where lithologies form a gradational trend from basal, thick conglomerates (Fig. 2A), to sandy conglomerates, coarse- to medium-grained sandstones and reworked tuffs with medium-grained sandstones. At Cerro de Las Hojas and Alto Río Bandurrias, medium- to fine-grained lithologies dominate the sequence, with cobble-size conglomerates, medium-grained sandstones and especially fine-grained siltstones with carbonaceous shales (Fig. 2B-D). The facies association of the Río Leona Formation in Sierra Baguales matches the proposed interpretation of Marensi *et al.* (2005), of meandering and anastomosing river systems, with variations in energy and sinuosity across space and/or time.

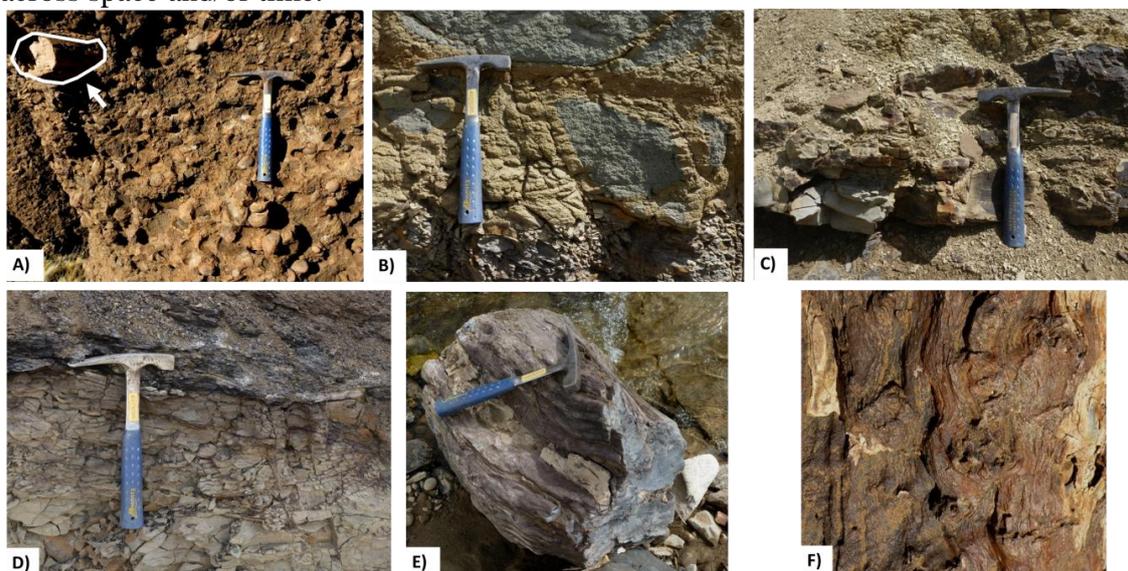


Figure 2: Distinctive lithologies and selected fossils of the Río Leona Formation in Sierra Baguales. A) Reddish brown, polymictic conglomerates. White arrow and contour show a trunk fragment embedded in the rocks. B) Fine- to medium-grained, orange-bluish sandstones. C) Shale interbedded with greenish siltstone. D) Carbonaceous laminated shales in fine-grained sandstones and siltstones. E) Reworked, large silicified trunk. F) Detail of the beautifully preserved bark in a fossil trunk.

Currently, at least 19 morphotypes have been recognized in the fossil flora (Fig. 3A-E). The dominant species (almost 90% of the samples) correspond to seven different morphotypes of deciduous *Nothofagus* Blume (Fig. 3C and D), identified as *N. simplicidens*, *N. densinervosa*, *N. variabilis*, *N. paleoalessandri*, *N. subferruginea*, *N. serrulata*, and *N. crenulata*. These morphotypes show a close similitude to modern analogues growing in the central part of Chile. The remaining flora include common specimens of Myrtaceae (Fig. 3A) and Lauraceae (Fig. 3B), Asteraceae, and less frequent species of Berberidaceae and Rosaceae, among others. Uncommon taxa are represented by rare specimens such as *Berberis* thorns (Fig. 3E), unidentified inflorescences, impressions of a conifer assigned to cf. *Lepidothamus fonckii*, and a preliminarily identification of *Eucalyptus chubutensis*. *Araucaria* sp. and fern leaf impressions were exclusively recovered at Anfiteatro de Las Araucarias and surrounding outcrops. Predation marks caused by insects and other trace fossils were observed in many of the leaf impressions. Fossil woods are currently being studied, but *Nothofagoxylon* sp. has been recognized. At three locations, fossil trunks were exposed *in situ* preserving their life position, a unique situation among Chilean Patagonian Cenozoic strata. Also, ichnofossils associated with some trunks fragments include good examples of *Teredolites* isp.

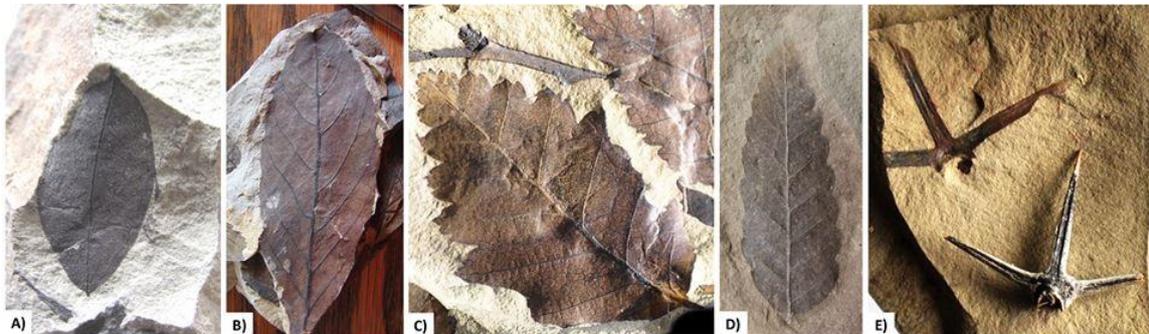


Figure 3: Fossil leaf impressions of the Río Leona Formation in Sierra Baguales. A) Myrtaceae: “*Myrcia*” *bagualensis*. B) Lauraceae: *Persea* sp. C) Nothofagaceae: *Nothofagus variabilis*. Leaves and associated twigs. D) Nothofagaceae: *Nothofagus* sp. E) Berberidaceae: *Berberis* sp. Fossil thorn impression contrasted with a modern thorn of Calafate, *Berberis microphylla*, for comparison.

DISCUSSION AND CONCLUSION

Marensi *et al.* (2005) suggest a river system with four fluvial styles for the deposition of the Río Leona Formation, some of which are also preserved in the Sierra Baguales sections, with higher energy facies towards the south.

The exhumed macroflora form a unique source of information on the history of the *Nothofagus* genus and the evolution of paleoclimatic conditions in Magallanes. The origin of the austral floral associations dominated by deciduous *Nothofagus* can be traced back to the late Paleogene, becoming widespread during the Early Neogene as testified to by different southern fossiliferous localities (i.e. Río Las Minas, El Salto, Río Guillermo; Panti, 2010). Warm to moderately temperate Mediterranean type conditions are here suggested for this flora, in accordance with their modern closest relatives within communities in the central Chilean deciduous forests. Based on the collected evidence, we infer paleoecological conditions in the Sierra Baguales similar to those presently existing in locations like the Maulino forests, or the Roble-Laurel-Lingue associations of central Bio-Bío. The occurrence of carbonaceous shale in the fine-grained upper units, also suggests that warm and humid, reducing conditions were present during their deposition, in concordance with the mesothermal character observed in the fossil flora.

The transitional contact between the Río Leona Formation and the Estancia 25 de Mayo Formation, dated between 20 to 19 Ma (Cuitiño *et al.* 2012), allows us to propose that at least part of the unit was deposited during Early Miocene times. Dating of other homologous units including the El Salto Formation in Chile and the Río Guillermo Formation in Argentina rendered U-Pb SHRIMP ages of 21.8 Ma and 21.7 Ma respectively (Hervé *et al.*, 2004; Fosdick *et al.*, 2011), also supporting a Neogene age for the Río Leona strata. This information challenges the assumed Late Eocene to Oligocene age for the deposition of this unit, but is consistent with the tectonic and stratigraphic information recovered from the Cenozoic portion of the fold-and-thrust belt.

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