

The La Cumbre-Baguales Geo-paleontological Park: an open window to the geobiotic evolution and ecosystem transformation of Patagonia during the Cenozoic

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The Sierra Baguales is a mountain range located in the northeastern part of the Última Esperanza Province, Magallanes, 140 km northeast of the city of Puerto Natales (Fig. 1). The area borders the Republic of Argentina to the north and east, while its western limit is formed by Sierra Contreras. Most of the land is privately owned and occupied by a dozen estancias (ranches) devoted to the rearing of cattle. The La Cumbre-Baguales Geo-paleontological Park is a private initiative generated on lands belonging to the estancias La Cumbre and Los Baguales, covering approximately 16,000 hectares (Fig. 1). The high ecological and scenic values of the area combined with the existence of an abundant fossil record, provides the stimulus for the creation of a new conservation unit in the area. Access to the park is almost always good and its proximity to the main tourist attraction of the region - the Torres del Paine National Park - transforms it into a major potential highlight, with future international projection.

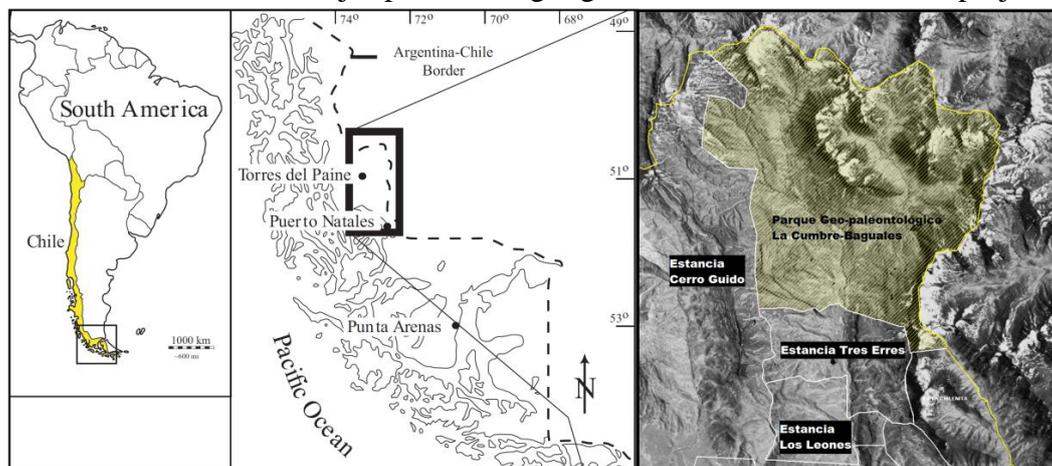


Figure 1: Park area with localities mentioned in the text (modified from Fildani *et al.*, 2007).

Native flora and fauna.

The park contains an important expression of the typical flora and fauna of the Magellanian/Patagonian steppe, an ecosystem type that is currently under-represented in the Public National Protected Areas System, SNASPE. Vertebrates are represented by about 25 species of birds, 11 species of mammals, 2 species of reptiles and 2 amphibians (Fig. 2A-D). More than 250 native plant species have been recorded so far in the area (Arroyo *et al.*, 1989).

Ecosystems and landscapes.

The ecosystems present in the park can be characterized as 1) gramineous steppe, 2) small alluvial plains, lakes and micro-wetlands, 3) high altitude dunes; and 4) the

high mountain. The landscape shows low anthropic intervention, expressed through semi-intensive cattle farming in the low meadows. The vegetation is characterized by the dominance of herbaceous species, which cover the park's surface almost entirely. The morphologic conditions define a visually impressive landscape, dominated by the towering cliffs of the igneous rocks that form the Sierra Baguales, rising more than 2,000 meters above the valley. There are several vantage points which allow long-distance multi-directional views (> 5000 m). The chromatic variability of the area is high, dominated by brown, green, yellow, reddish and gray colors, mostly related to the soils, the vegetation cover, and the exposed rocks. The scenic background of the area is made up of asymmetrical surfaces, dominated by reddish and gray colors. All these conditions create great visual impact and overwhelming scenery for visitors (Fig. 2E-G).



Figure 2: Distinctive attributes and activities developed in the La Cumbre-Baguales Geopaleontological Park. A) Vigilant male guanaco (*Lama guanicoe*) and volcanic mountains, iconic symbols of the park. B) Colored lichens. C) “Zapatito de la virgen” flower (*Calceolaria uniflora*). D) Guanaco herd grazing in the steppe. E) Landscape image of the vegetation cover and the Sierra Baguales igneous complex at Río Bandurrias. F) Alto Río Baguales valley, future headquarters of the park's administrative office. G) Cerro sin nombre, one of the many mountains built by the Mio-Pleistocene magmatic activity. H) Paleontological team of the Anillo Project and Argentinean colleagues during the summer field season of 2013. I) Students and teachers of the international “Biodiversity and Conservation” course, during a field trip to the park, in March 2013.

Lithostratigraphic units and their paleoenvironments.

The purpose of the park aims to add scientific and cultural value to the local tourist attractions, highlighting the large geological and fossiliferous diversity present in the lithostratigraphic units of the area. Description, characterization and stratigraphic mapping have been undertaken from 2010 to 2013, as one of the activities performed by the Anillo de Ciencia Antártica project (i.e. Bostelmann *et al.*, in press; Gutiérrez *et al.*, this symposium). The paleontological studies carried out by the Anillo Project team also mark a historical breakthrough in relation to the available knowledge of the past biodiversity in Magallanes. The stratigraphic units range from the middle Eocene to the late Holocene, forming a unique register of the evolution of the Cenozoic southern ecosystems. A brief description of the succession present in the park is provided below.

Man Aike Formation (Middle to Late Eocene): This lithostratigraphic unit is composed of conglomerates, glauconitic sandstones and siltstone lenses, forming different facies of a shallow subtropical sea and estuary. The great fossil diversity includes leaf imprints with megathermal affinities; abundant traces, marine invertebrates, mainly bivalves, brachiopods and gastropods (Griffin, obs. pers.); and vertebrates, represented by more than 25 species of cartilaginous fishes (Otero *et al.*, in press), crocodile remains, turtles (Otero *et al.*, 2012) and archaeocetes. The Man Aike Formation was deposited during a eustatic pulse associated with a global climatic optimum at 40 Ma, recognized as the Middle Eocene Climatic Optimum (MECO).

Río Leona Formation (Late Oligocene - Early Miocene): Conglomerates, sandstones, siltstones and carbonaceous lenses compose this unit. The whole package was deposited in a fluvial system with meandering rivers and anastomosed streams, under a warm-maritime climatic regime. Its fossil content includes one of the best preserved South American early Neogene flora (Torres *et al.*, 2009, this symposium), represented by exquisitely preserved leaf imprints and plentiful fossil trunks. Fossil traces in the plants include insect predation marks and *Teredolites* isp. A study of this flora currently under way has characterized these forests as stands dominated by *Nothofagus* and Myrtaceae, like the current deciduous forests of central Chile, representing the first manifestation of Mediterranean ecosystems of South America.

Estancia 25 de Mayo Formation (Early Miocene): This formation corresponds to the local expression of the “Patagonian” sea at Sierra Baguales. The numerous species of marine invertebrates present in the unit includes gastropods, bivalves, brachiopods, crustacean decapods, barnacles, and bryozoans; most of which still preserve their original composition. The assemblage shows clear affinities with the Monte León Formation marine fauna, recorded along the Atlantic coast of Argentina (Griffin, pers. obs., 2013), which characterize a subtropical shallow sea. A conspicuous yellow tuff horizon located in the lower third of the unit acts as a regional guide level, and represents the products of an explosive volcanic event carried to the basin by a hyperpycnal flow at 19.1 Ma (Cuitiño *et al.*, 2013, Gutiérrez *et al.*, this symposium).

Santa Cruz Formation (Early Miocene): These deposits include mainly fluvial continental units, with some alluvial plain facies (Bostelmann *et al.*, in press). A diverse terrestrial fauna contain more than 25 vertebrate species, mainly mammals, with “Notohippian” age affinities. Traces, leaf imprints, trunks and *Crassostrea orbigny* reefs are located in the basal strata, attesting an estuarine transition towards the fully-continental deposition. The Santa Cruz Formation sediments have fundamental relevance for interpretation of the timing of the Austral Andean uplift (Bostelmann *et al.*, in press).

Sierra Baguales igneous complex (Middle Miocene? – Pleistocene): Several volcanic flows compose the characteristic mountain silhouette of Sierra Baguales. The horizontally disposed magmatic units are commonly intruded by younger dikes and sills. Unfortunately, only limited knowledge of their composition and emplacement history is available at present (Muñoz, 1982). An alkaline to sub-alkaline signature has been traditionally proposed for all these volcanic products.

Quaternary infill (Late Pleistocene - Holocene): The Quaternary infill mainly includes glacio-fluvial deposits distributed over the entire park, filling valleys and forming the shores of rivers and streams. Tephra horizons can be observed in most of these outcrops, related to volcanic events that occurred during the Late Holocene.

Cultural attributes.

The abundant archaeological patrimony present in the park includes at least 6 identified sites composed by lithic workshops, and associated pieces such as projectile

points, chips, “boleadoras” and scrapers. Identified pictographies in the upper course of the Baguales River represent the first manifestation of rupestrian art in this part of Chilean territory.

Management.

The park initiation has been scheduled for the beginning of the 2014/2015 season. The Management Plan of the park will be finished by the end of 2013, establishing the formal guidelines and general restrictions to the activities undertaken by visitors. During 2014, the construction of the Environmental Interpretation Center will be finished, which will serve as the administrative headquarters of the park. This will also include the opening of a field laboratory, oriented to scientific activities. Agreements on research activities and tourism development through scientific knowledge have been established with the adjacent estancias, aimed at involving these territories in a Geopaleontological conservation program including the entire area of Sierra Baguales and Cerro Guido. A long term goal will include the consolidation of links with similar projects across the international border, in the Argentinean Republic.

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