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The Evolution of the Chilean-Argentinean Andes

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For our partners of marvelous voyages through the Andes

Preface

This book analyzes the tectonic evolution of the Argentinean and Chilean Andes through four parts: the first dealing with the structure of the fore-arc from bathymetric, gravimetric, and seismic data; the second part that discusses the Paleozoic evolution of this sector, first showing the paleomagnetic behavior of the continent during this period and then discussing the different hypothesis associated with the accretion of continental slivers and consequent closure of ocean basins, producing deformation and metamorphism, reconstructing the geometry of the Early Paleozoic orogens and arcs across South American western sector; the third part that analyzes the proto-Andean arc evolution, showing the paleomagnetic path of the margin, clues about its early arc activity, its relation to LIP activity associated with Pangea supercontinent desintegration and subduction zone; the fourth part that discusses early development of the Andes that started as a non-organized collage of within-plate deformation sectors that lately established next to the subduction zone when the south Atlantic Ocean started to expand; and finally, the fifth part that discusses different aspects of the Cenozoic evolution of the Andes and its contemporaneous volcanic arc, such as development of shallow subduction settings through time, the role of dynamic subsidence, opening and closure of intra- and back-arc basins.

In detail, the first part is composed of three chapters. The first chapter by Contreras Reyes et al. analyzes from wide-angle seismic data the structure of the submerged fore-arc as a result of the balance between sediment accretion and sediment subduction and crustal erosion. Then, different segments are subdivided that are characterized by dominant frontal erosion or accretion and are defined by climate conditions, sediment dispersal pattern along the trench, and subduction of bathymetric highs. The second chapter by Maksymowicz and Tassara analyzes the geometry of the submerged frontal prism as a function of basal and poral pressure conditions. Those systems that are subjected to frontal crustal erosion become oversteepened since these are affected by normal faulting that triggers internal saturation with seawater. Additionally, this chapter highlights the role of these morphological variations on seismic segmentation along the subduction zone. The third chapter in this first part belongs to Álvarez et al. and analyzes vertical

gradients in gravity anomalies and their relation to co- and post-seismic rupture zones of giant earthquakes along the subduction zone and their complex internal structure. Additionally, satellite measurements can show changes in the gravity field that could be used to predict rupture propagation along the subduction zone. Then, variable fore-arc structure revealed by gravity data shows to have an important influence in the way that ruptures propagate and therefore in seismic segmentation and their potential.

The second part starts with Rapalini et al. chapter that deals with paleomagnetic reconstructions that describe South American path as part of Gondwana during the Paleozoic. The second chapter by Heredia et al. discusses the complex collage of continental slivers that have formed the western Gondwana border that is being reconstructed on the basis of the recognition of different deformational vergences, superimposed metamorphic and deformational events, and recognition of internal and external parts of collisional orogens. The third chapter by Ramos is a reconstruction of the Early Paleozoic arc and consequently the western border of Gondwana, allowing identifying subsequent crustal accretions though differential exhumation levels preserved along the margin.

The third part starts with Oliveros et al. chapter that analyzes magmatism in northern Chile showing that arc activity had already established since the Triassic, a period that had been considered devoid of subduction processes in western Gondwana. A short lapse characterized by a decrease in magmatic activity appeared at the time when the arc established nearer the subduction zone, at the time when the crust became less assimilated by mantle derived products. Naipauer et al. discuss this same magmatic stage in Northern Patagonia discussing its relation to the proto-Pacific border and LIP activity in the Karoo-Ferrar anomaly, concluding that at these latitudes plume activity influenced considerably composition of near-trench magmatism.

The fourth part starts with Iglesia Llanos chapter that analyzes using paleo-magnetic data the path of southern Gondwana in Jurassic times. During this time the supercontinent experiments important latitudinal variations, first displacing to the north, and then returning to southern latitudes. Continental absolute displacements together with the opening of the Weddell Sea at southern Gondwana are the clue to explain within-plate deformations in Patagonia, analyzed in the second chapter by Navarrete et al. This chapter also describes early deformations through the western border of Patagonia at the time of South Atlantic opening. These proto-Andean deformations are also recorded in northern Chile, lately reactivated during the development of the Neogene Chilean-Pampean flat subduction zone, as it is described in the third chapter made by Martínez et al., Gianni et al. in the fourth chapter study synorogenic sedimentation in Northern Patagonia and southern Central Andes showing a diachronism in the uplift of the Cretaceous proto-Andes. This is interpreted as due to the subduction of active ocean ridges that are depicted in recent plate models. The next chapter by Arriagada analyzes first-order inflections of the South American subduction border using paleomagnetic data, determining their origin as oroclines formed diachronously and linked to basement heterogeneities associated with crustal amalgamation in Proterozoic to Paleozoic

times. Finally in this part, the chapter of Iannelli et al. calculates ancient crustal thicknesses and degree of influence of the subduction slab on arc-related rocks of Paleogene age, determining that the Andean roots produced during the proto-Andean evolution times were practically lost during Eocene to Oligocene extensional stages along the Southern Andes. This crustal stretching could have developed in relation to the combination of an opening of a slab window during mid-ocean ridge subduction and trench rollback.

The fifth part starts with Dávila et al. chapter that quantifies subsidence and uplift influenced by the mantle dynamics, superimposed to tectonic topography. This chapter predicts within-plate subsidence next to flat subduction settings and discusses subsidence components in ancient rift systems that cannot be fully explained by thermal decay, such as the Triassic rift systems in central Argentina. Additionally, this chapter analyzes mantle upwelling component associated with Neopaleozoic regional uplift and glacial activity in southern Gondwana. The second chapter by Lossada et al. is a review centered on the Frontal Cordillera uplift constituting the major mountain system developed in central Argentina whose origin was thought to be associated with the development of Chilean-Pampean flat subduction zone. Thermochronological data show that exhumation of this system is previous to the development of the flat subduction and is most likely influenced by preexisting heterogeneities linked to the Gondwana breakup. The third chapter by Turienzo et al. analyzes mechanics of deformation of fold and thrust belt at the Southern Central Andes suggesting that shortenings have been somehow underestimated and that the structure could be considerably more complex than previously assumed. The fourth chapter by Encinas et al. discusses subsidence mechanisms associated with the Late Oligocene to Early Miocene transgressions in Patagonia as part of the rifting activity that started in Eocene times and continued in the Early Neogene, as broad sag basins that flooded most of the ancient collapsed Andes. The fifth chapter by Folguera et al. analyzes Cenozoic deformations of the North Patagonian Andes from the study of synorogenic sedimentation. This concludes that an intra-arc basin closure and a shallowing of the subducted slab could have contributed together to the Neogene uplift of western Patagonia. In the sixth chapter, Litvak et al. study arc-related composition of magmatism associated with the development of the Chilean-Pampean flat subduction zone and Payenia shallow subduction setting to the south, concluding that most likely these behaved as one single system in the 15–4 Ma period. Finally, the seventh chapter by Collo et al. constitutes a compilation of heat flow from wells that illustrate how the Chilean-Pampean flat subduction zone has refrigerated the lithosphere, expelling the mantle asthenosphere off the shallow configuration as shown in Fig. 1.

Buenos Aires, Argentina Andrés Folguera et al.

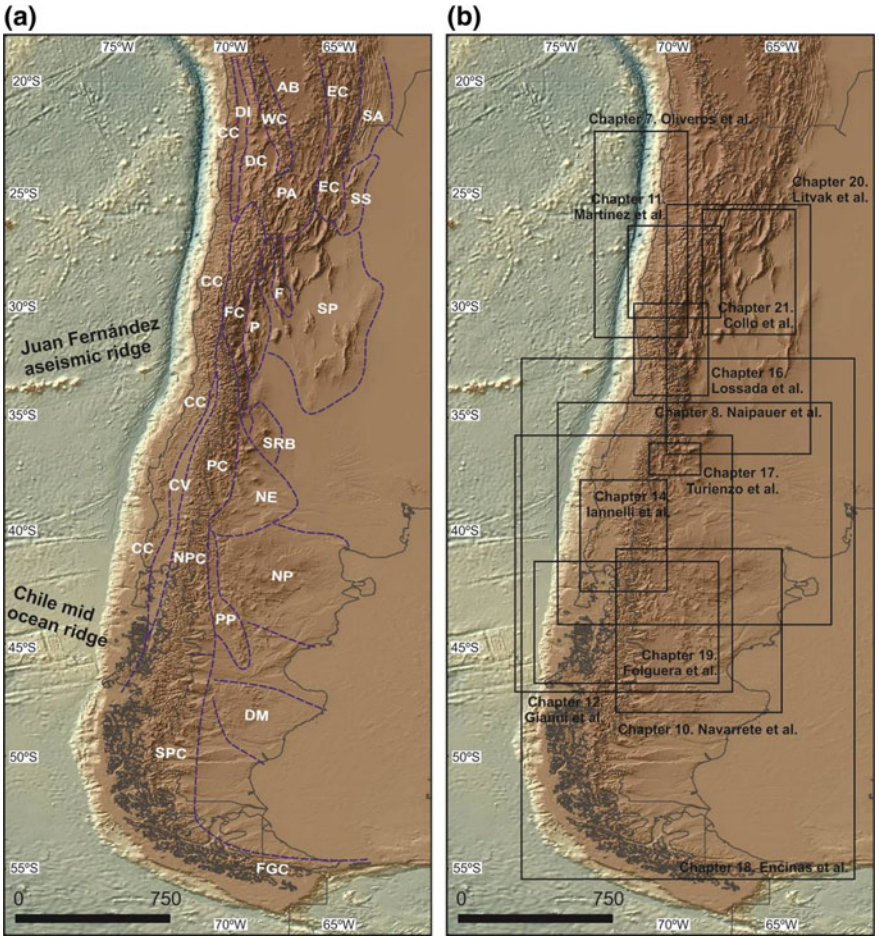

Fig. 1 To the left: Main morphostructural provinces in which the Southern Andes are divided. CC: Cordillera de la Costa, DI: Depresión Intermedia, DC: Cordillera de Domeyko, WC: Cordillera Occidental; PA: Puna; AB: Altiplano Boliviano; EC: Cordillera Oriental; SA: Sierras Subandinas; SS: Sistema de Santa Bárbara; FC: Cordillera Frontal; P: Precordillera; F: Sistema de Famatina; SP: Sierras Pampeanas; CV: Valle Central; PC: Cordillera Principal; NE: Engolfamiento Neuquino; SRB: Bloque de San Rafael; NPC: Cordillera Norpatagónica; PP: Precordillera Patagónica; NP: Macizo Norpatagónico; SPC: Cordillera Surpatagónica; DM: Macizo del Deseado; FGC: Cordillera Fueguina. To the right: book structure (empty rectangles indicate areas analyzed in each chapter)

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