PHD RESEARCH PROJECT

CORDILLERAN-TYPE MOUNTAIN BUILDING AND SUBDUCTION GEOMETRY: INSIGHTS FROM THE ANDEAN OROGENIC SEGMENT

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ERC Sector: PE10

- GENERAL PRESENTATION OF THE PROJECT AND STATE OF THE ART

Mountain building in cordilleran-type orogens such as the Andes is controlled by various processes. It has been demonstrated that continental shortening and uplift in the Andes are largely related to the geometry of the subducting slab, but no model adequately explains this type of orogens. The Andes are especially important because they span across several global climate zones and influence ocean circulation and climate. Yet, a comprehensive time-space framework linking processes and mechanisms controlling the architecture and morphology of the Andes is still lacking. This is mainly because there is no well-established relationship among the differences in crustal thickness, continental plate architecture, deeper mantle processes, shortening and width of the Andes, and differences in erosion and climate. The total amount of shortening (200-500 km [1]) in the central Andes at the latitude of northern Chile is much larger than that (<50 km [2]) of the southern Andes between 33 and 40°S. This difference in shortening, which could explain why the central Andes are wider and higher than the southern Andes, has been proposed to result either from processes related to subduction dynamics or to a retroaction of climate on tectonics [3]. On the other hand, it has been shown that both continental shortening and uplift are larger above flat slab segments [4,5], and that tectonic episodes responsible for the growth of the Andes may be largely related to the geometry of the subducting slab [6,7].

- RESEARCH OBJECTIVES

The aim of this project is to analyse the spatio-temporal history of deformation, uplift and subsidence, by comparing surface geology and geomorphology with the geometry of the lower and upper plates along three transects characterized by different physical configurations. The geodynamic framework is provided by lithosphere-scale models displaying the position of the subducting slab through time and the present slab geometry. This research integrates structural geology, low temperature thermochronology, tectonic geomorphology as well as thermal and geodynamic modelling to investigate the effects of slab geometry, ridge subduction and forearc underplating on mountain building and surface evolution in different climatic settings. The project will improve our understanding of the dynamics of cordilleran-type orogenic systems, also advancing the state of knowledge about the conditions necessary for subduction margin orogeny, and how to recognize these processes in modern topography and the geological record. This work will compare observations to model output based on existing geodynamic and lithosphere-scale models, thus producing a framework for a better evaluation of different controls on mountain building and surface uplift, with implications for geohazards and georesources and, at a broader scale, for ocean circulation, climate, and biodiversity.

- METHODOLOGY AND EXPECTED RESULTS

The first objective of the research are the gathering, analysis, and interpretation of structural data, in order to construct balanced and restored sections of the area; To this aim techniques of structural analyses (based on systematic observations and measurement of bedding, cleavage, fractures, faults and related kinematic indicators; and of fold parameters), cross-section balancing and restoration will be applied in classic fold and thrust belt tectonic studies. The second objective is to create a thermal modelling that shows the thermal structure of each regional cross-section. In particular, a 2-D elastic finite element model (FEM) will be discretized in order to simulate interseismic stress and strain accumulation, and to obtain information on the vertical surface displacement associated with both interseismic and coseismic stages in tectonically active regions. Modelling will be carried out using a FEM, a method analyses the inter-seismic deformation characterizing zones of plate convergence as a result of the elastic strain affecting a brittle layer resting above a ductile half-space [8,9]. Using the same numerical method, the co-seismic deformation associated with a specific seismic event can also be modelled. The methodology of 2-D FEM consists of the geometric construction of a model containing the fault setting of interest. The outcomes of finite element modelling will be compared with information on the space-time distribution of surface vertical motions inferred from the tectonic geomorphology analysis. In this way, we will use a topographic analysis in combination with lithologic boundary conditions to study the locus of recent uplift and then combine it with a FEM to explore the tectonic processes (specifically inter-seismic and co-seismic deformation) that could explain the pattern of uplift. The results of this work will allow us to obtain a comprehensive model of the evolution of topography in response to the vertical component of surface displacement along each studied section. Besides increasing our understanding of the active tectonic behaviour in the study area, this part of the research project is aimed at providing new, general insights into the processes controlling relief evolution in areas affected by large thrust earthquakes.

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