Geophysical Research Abstracts
Vol. 21, EGU2019-18323-1, 2019
EGU General Assembly 2019

Understanding connections between megathrust earthquakes, crustal deformation and volcanism along the Southern Andes

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The mechanism by which large megathrust earthquakes, upper crustal faults and volcanoes interact at subduction zones at different spatial and time scales are still poorly understood. The Southern Volcanic Zone (SVZ) of the Southamerican Andes (33°-46°S) is an ideal place to study these connections because of the very active nature of this region, particularly during the last decade, and a well-documented link between long-term tectonics and magmatism. Along the southern SVZ (south of 38°S), extensional and compressional regimes are created at the intersection of a trench-parallel structural system (the Liquiñe-Ofqui Fault Zone, LOFZ) with oblique NE- and NW-oriented faults. Contrasting stress conditions at these intersections favor respectively the rapid ascent of basic magmas from lower crust (e.g. Llaima volcano LLV) or upper crustal stagnation and differentiation toward acidic magmas (e.g. Puyehue-Cordon Caulle Volcanic Complex PCCVC). Along the Northern SVZ, a dominance of intermediate-to-acidic volcanism is associated to prevailing compressive structures linked with Neogene fold-thrust belts (e.g. Laguna del Maule Volcanic Complex LMVC). This explains the first-order spatial distribution of volcanic products along the SVZ but is only valid under the stress regime imposed by the oblique convergence between Nazca and Sudamerica during the interseismic phase of the megathrust seismic cycle when both plates are coupled. However, eruptions are statistically more common after large megathrust earthquakes that presumably develop a transient but likely large-scale perturbation (even reversion) of the interseismic stress field. We recognize this apparent paradox and consider the occurrence of the great (Mw8.8) Maule 2010 earthquake as an opportunity to get deeper insights into the relationship between megathrust seismic cycle, active crustal faulting and volcanism at different spatio-temporal scales. Our research combines a) field-based kinematic and dynamic analysis of basement structure below 9 selected volcanoes and integrated at the scale of the entire SVZ, b) temporal evolution of deformation field by geodetic data (InSAR and GPS) and seismicity for the end-member cases of LMVC, LLV y PCCVC, and for the SVZ as a whole, c) characterization of the 3D compositional, thermal and mechanical structure of the Andean margin as derived from a compilation of geophysical data and models. After several years of research we are currently integrating these observations into a unified conceptual model on the relationship between megathrust earthquake cycle, crustal deformation, active tectonics and volcanism valid for the Southern Andes, which we hope would become significant for the understanding of these connections in other active subduction margins. We will present here a synthesis of this research and the conceptual model that we want to propose to the community.