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Editorial

Analysis of the Quaternary climatic and tectonic forcing along some different tectonic settings of South America

This special issue includes some of the contributions presented at Workshops of the INQUA SAm-GeoQuat International Focus Group (IFG): "South American Project towards an integration and improvement of Quaternary geological data" (years 2013/2015), sponsored by the Commission on Terrestrial Processes, Deposits and History (TERPRO) of INQUA. This IFG was mainly composed of researchers in Quaternary Geology from South American countries. The associated 1311 INQUA Project SAQint3: "Interactions between climatic forcing, tectonics and volcanism during the Late Quaternary: a multidisciplinary approach applied on key regions of South America" was dedicated to reinforce the interactions and feedback between specialists in neotectonics and geoscientists working on surface processes that influenced actively the landscape. Field meetings, workshops and field courses sponsored by the INQUA project allowed many researchers with different geological backgrounds to meet and discuss common approaches for studying the interactions between Quaternary climatic forcing, tectonics and volcanism along a variety of tectonic settings of the continent.

Some papers related to the advances in the project area of South America are integrated in this special issue, dedicated to a comprehensive analysis of climate and tectonic influences on terrestrial processes of representative regions during the Quaternary. Most of the authors are South American researches and also members of the IFG and the project, being some of the first authors earlier career researchers.

Continental records from South America such as loess-palaeosols sequences, lacustrine sediments, floodplain sediments, glacial and coastal deposits, between others, were used to reconstruct environmental response to climatic changes in the last years. Independently, some studies are focused on the influence of volcanism and tectonics on the Quaternary landscape evolution. In the Andean region, tectonic and volcanic processes generated significant changes in the landscape, in interaction with glacial, physical weathering, fluvial and mass transports processes. For intraplate extra-Andean regions, surface deformation occurred also at unexpected locations, but with relative slow displacement rates.

This volume pretends to integrate some advances related to the distinction of features caused by major climatic changes from environmental variations induced by local or regional factors such as volcano-tectonic forcings along some representative regions and on a regional scale. These are very important to enhance integrated analyses of the exogenic versus endogenic processes interplay on the Quaternary landscape evolution for more accurate palaeoenvironmental reconstructions. Not all of the papers of this volume refer to interactions occurring in the same space or time, but some of the contributions focus on some processes that can trigger or enhance a different process. Numerical estimates of climate driven surface and/or tectonic processes interplaying in different geological environments of the continent are included in some papers.

Garcia et al. present an integral mapping of glaciers and ice-bearing periglacial landforms in a key region of the arid/hyperarid Central Andes (Atacama Region) of Northern Chile. They document under the present climate a gradual change of the composition of the cryosphere as aridity increases (a latitudinal variation entering in the South American hyperarid axis), and being it of great importance when past climate changes are reconstructed in relation to the regional ice-budget changes. Also the combined glacial and periglacial inventory of ice-bearing bodies provide the society a more realistic view of the distribution of the cryospheric hydrological resources in arid regions.

Cabré Cano et al. address the Late Quaternary landscape evolution of a representative fluvial basin of the semiarid Central Andes of Northern Chile. ^{14}C AMS age data indicate that the aggradation in the uppermost part of the El Tránsito river valley immediately postdates the glacial retreat in the upper basin at ca. 15 ka. cal. BP and spans most of the Holocene. The Holocene aggradation cycle is not only fully explained by a paraglacial readjustment of glacigenic sediments from the glacial segment of the valley due to a shift to wetter conditions, which could have enhanced the paraglacial response. Their results suggest that the Holocene river dynamic is perturbed by local factors (e.g. lithology and shallow seismicity). The diachronous infilling of the main fluvial valley highlights that slope dynamics, tributary catchments characteristics and landslide activity should be taken into account when using fluvial stratigraphy in palaeoclimatic reconstructions.

The paper of **Sielfeld et al.** focuses on the analysis of the evolution of a sector of the Andean Principal Cordillera in Central-Southern Chile and the relationships between regional tectonics and volcanism. On basis of field mapping and remote sensing data, interactions among volcano anatomy, regional differential tectonic stresses, edifice-load and erosional pattern are considered. The authors evaluate how dykes and minor eruptive vents within the Callaqui Stratovolcano emplaced on a transitional segment between Central and Patagonian Andes can be organized in time and space by the operating tectonic field, inherited structural anisotropies and the localized effect of volcano edifice shape and load.

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The right lateral transtensional kinematics constrained the volcanic output along eruptive fissures, proposing that Plio-Quaternary reactivation of optimally-oriented inherited basement fault would enhance the development of discrete transtensional domains across the first-order intra-arc fault system. Pleistocene-Holocene eruptions enhanced by transtensional kinematics would contribute to the Callaqui-Copahue-Mandolehue volcanic chain building process. Their results contribute to understand the tectonic role in magma migration processes within the upper crust, which is crucial to understand geothermal systems and to minimize hazards related to volcano instability.

The glacial chronology of the Plata Range (Frontal Cordillera) in the arid Central Andes of Argentina is presented by **Moreiras et al.** The authors differentiate the main Quaternary deposits and glacial landforms through remote sensing and field inspections in the Blanco River Basin. Terrestrial Cosmogenic Nuclide datings on glacial deposits show that at least three Late Pleistocene/Holocene glacial advances occurred, two of them (8–25 ka. BP) related to the Last Glacial Maximum and appearing only at higher altitudes in the basin. According to their results, chronological data of deformed units, seismic triggered rock avalanches and out setting alluvial fans are older than the identified glacial advances.

Vázquez et al. evaluate the utility of geomorphic surfaces deformed by propagating thrusts underneath, through the use of techniques applied in structural geology. They investigate Late Pleistocene alluvial surfaces interacting with exogenous processes and their relation with tectonic processes driving the geomorphic expression of scarps, related to Quaternary-active thrust splays propagating in alluvial bajadas. The study area comprises the Las Peñas Thrust, in the eastern piedmont of Southern Precordillera of Argentina (the southernmost section of the Pampean flat-slab of the Andes prominent), where Quaternary deformation and ongoing seismicity at the back-arc is concentrated. Geometric parameters of causative structures were used to constrain balanced cross-sections through trishear modelling for shortening estimation and also for comparing the predicted geometry with the scarp profile. Trishear models predict shortening values 8 to 15 times larger than those obtained through line retro-deformation of scarp profiles. Their data indicate that scarp shapes at a mesoscopic scale are not considered a reliable deformation marker for shortening estimation of propagating thrusts through an unconsolidated cover. These results cannot account for all possible scenarios derived from fault-propagation folding but give a warning on the use of models to derive shortening estimations from topographic observations.

Denudation of surface materials results from the rates of uplift and removal by fluvial processes, being an interesting proxy. In this subject, **Nóbile et al**. explore the relationship between catchment-scale erosion rates derived from cosmogenic ^{10}Be, catchment geomorphometric parameters and longitudinal river profile channel steepness index within the Ambato Range of the Pampean Ranges, the easternmost elevations of the Argentine broken foreland of the southern Central Andes. They use concentrations of ^{10}Be cosmogenic radionuclide in river sediments from catchments of the eastern slope of the Ambato Range (ranging between 0.038 and 0.12 mm/yr) to understand the relationship among short-term (106 yr) catchment-wide denudation rates and mean long-term denudation rates estimated from geologic data in previous contributions (0.34 mm/yr). The authors find a strong positive correlation between erosion rates and channel steepness index providing a reliable metric of denudation rates in tectonically active landscapes. At a regional scale they compare their results with similar studies along the Central Andes foreland to discuss the influence of tectonics, climate and lithology on the erosion rates.

Previous research reported Quaternary tectonics and seismicity in the Brazilian continental margin. The role of the reactivation of Precambrian basement fabric in the geomorphological evolution of the Paraíba Basin during the Cenozoic is analyzed by **Lima et al.** This basin, located in the coastal region of northeastern Brazil, represents part of the last bridge between South America and Africa before the last breakup stage of the South Atlantic rifting in the Early Cretaceous. Based on the integration of remote sensing, topographic, aeromagnetic, wellbore and field data, authors show that the shear zones are long-lived structures that have behaved as weakness zones. The deformation in the continental margin has generated syn-sedimentary faulting and a system of grabens and horsts that remained active through Neogene-Quaternary times. This pattern of repeated fault reactivation has controlled sediment deposition and landform development, as observed in other coastal basins along the Atlantic margin of South America.

Craton-related basins of South America, as the Pantanal and Paraná basins, are key areas for the analyses of tectonics and fluvial processes interaction. The study of one of the largest Quaternary megafans in tropical lowlands is addressed by **Pupim et al.** The Cuiabá alluvial fan is part of the Brazilian Pantanal wetland, a tectonically active sedimentary basin associated with the Andean foreland system. Their approach was based on remote sensing methods coupled to field surveys to characterize the geomorphic features and historic hydrological data as well as to optically stimulated luminescence (OSL) dating of sediments to establish the succession of depositional and erosional events that that built up the megafan since the MIS 3 period. Results indicate that the location of the megafan results from the accommodation space produced by long-term tectonic processes, with precipitation changes playing a major role in aggradation and incision phases as well as shifts in the fluvial channel patterns. This variation in precipitation is related by the authors to changes in the South American monsoon strength.

Milana and Kröhling analyze the Puna-Altiplano Plateau of the Central Andes (Argentina, Chile and Bolivia) as a source area of sediments composing Quaternary loess units of the Chaco-Pampa plains (Argentina), characterized by a high participation of volcanoclastic materials. Pampean loess is the most extensive in the Southern Hemisphere and although it has been related to multiple dust source areas, it was mainly linked to the southwestern Central Andes/North Patagonian source. The research focuses on the dynamics and the type of material that wind place in suspension and saltation in the Purulla depression, southern Puna Plateau in Argentina. Purulla is mainly formed by Late Pleistocene pyroclastic deposits, being a unique natural laboratory for the development of extreme aeolian landforms. Their results, also including a volumetric balance of sediments, prove that the plateau dust supply is active and that it is exporting fine grained material to the large plain, as was also indicated by meteorological reports using satellite imagery. The paper is the first attempt to characterize the relation between the aeolian erosion in the Puna Plateau and the dust deposition in the Chaco-Pampa and neighboring regions during the Late Quaternary.

Investigations on tectonics and fluvial incision along the intraplate domain of South America are incomplete and poorly documented in comparison to studies developed for the tectonically active mountain environments. Furthermore the research on low uplift rate settings of the continent is lacking comprehensive modelling approaches. The analysis of the geomorphic and tectonic rates in a representative area of the Argentine Chaco-Paraná intracratonic basin is the target of the paper by **Brunetto et al.** The authors prove that a geomorphological modelling stratigraphically constrained and based on the stream power law, which integrates uplift, fluvial incision, and diffusion of sediments, is possible to be applied in lowland landscapes as the Northern Pampa plain. Their estimations evidence highly dynamic surface and tectonic

processes controlling the landscape evolution over intermediate time-scales (1×10^5yr). This leads to a discussion about why rapid geomorphic evolution can occur for the Late Pleistocene/Holocene in intracratonic regions like the Northern Pampa foreland basin, characterized by a long-term history of subsidence.

The interaction between different climatic forcing factors since the Late Holocene in different lowland areas of South America is addressed by Guerra et al., Córdoba et al. and Milana et al. The paper of **Guerra et al.** analyzes geochemical, sedimentological, historical and instrumental data from the Melincué Lake in order to reconstruct main hydro-climatic changes along the Northern Pampa region. According to the authors, the comparison of the paleolimnological reconstruction from this shallow lake to different hydrological and paleoclimatic records suggests that the moisture variation registered between the Little Ice Age and the Current Warm Period is consistent with large-scale climatic oscillations. Their results highlighted the value of the shallow Pampean lacustrine systems as sensors of regional changes associated to the South American Monsoon system activity, providing a better understanding of the hydrological response of these systems under climatic change scenarios for planning sustainable development strategies in vulnerable lake-shore communities along the populated Pampa Plain. **Córdoba et al.** report ^{210}Pb data from two sediment cores collected from Lagunas Encadenadas del Oeste shallow lacustrine system in order to establish the chronologies and sediment accumulation rates recorded in the lake sediments accumulated under highly variable hydrological settings in the Southern Pampa during the last century. The authors determine the most suitable ^{210}Pb-based numerical model to be used for this type of systems to calibrate proxy records for reconstructing environmental changes during the Anthropocene and previous centuries. **Milana et al.** study the recent coastal evolution of southeastern Brazil, presenting the first geochronometric analysis of a large succession of coastal ridges of the south of Rio Grande do Sul inlet. These landforms represent one of the most complete geoarchives to unravel the Holocene coastal history of Brazil after the 6 ka. BP highstand, contributing to the reconstruction of the recent climate history of the Atlantic margin of South America. Satellite imagery mapping of the ridge succession, field data and OSL datings lead to the authors to define epochs of enhanced coastal dynamics alternating with epochs of fluvial transport along the Rio Grande estuary. Both longshore drift changes detected for them are related to pervasive changes in wind activity, with the highest wind effects extended between 3.9 and 2.6 ka. BP.

The results and original approaches presented in the papers of this special issue underscore the importance of geological multidisciplinary studies in furthering knowledge and understanding of different environments of South America.

I would like to warmly thank all those colleagues who attended the SAm-GeoQuat IFG meetings, and very especially who contributed to this volume. I am immensely grateful to the reviewers who gave their time and effort in reading and improving the quality of the submitted manuscripts. I also would like to gratefully thank to the Editor-in-Chief Dr. Min-Te Chen and the Associate Editor Dr. Asrat Asfawossen, who accepted our proposal of publication and for their assistance along the editorial process. Finally, I acknowledge to INQUA and TERPRO for partially supporting the organization of the international meetings organized in different countries of South America between 2013 and 2015.

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