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25th Latin-American Colloquium of Geosciences

Hamburg, Germany
September 18 - 21, 2019

Program and Abstracts

Universität Hamburg
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Edited by Ulrich Riller & Paul Göllner

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LAC 2019

25th Latin-American Colloquium of Geosciences
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Welcome to the 25th Latin-American Colloquium of Geosciences!

Collaborative research in the Geosciences between German and Latin-American scientists has a long tradition in Germany. Based on this tradition and efforts to disseminate research results and to foster collaboration, the Latin-American Colloquium (LAC) was established in 1972. Over the years, the LAC has advanced as an important international venue to showcase projects supported by the German Science Foundation, the German Academic Exchange Service, the Alexander von Humboldt Foundation, Germany's Federal Ministry of Science and Technology, and other funding bodies. Many of the featured collaborative projects are highly interdisciplinary and span from marine geology and geophysics, structural geology, paleontology, mineralogy, sedimentology to paleoclimate studies, geomorphology and the impact of humankind on erosion and climate change. Given the challenges that geoscientists are confronted with today, this Earth System Science format of the conference is timely and helps foment interdisciplinary thinking and the establishment of new alliances. As such, the LAC follows the Earth System Science approach of Alexander von Humboldt and his efforts to communicate scientific results to the public.

In the tradition of the holistic approach of Alexander von Humboldt in approaching complex research problems, the LAC will celebrate transdisciplinary milestones achieved through German-Latin American cooperation in the geosciences. It will also highlight the results of individual research projects and identify future avenues of cooperation. The following topics will be central to the LAC:

- Ocean-continent transition,
- Continental growth and modification,
- Earth-surface processes and their climatic and tectonic forcings.

The main topics of the LAC will be complemented by contributions regarding methodological and technical advances, collection-based and paleo-environmental research, and resource formation. The scientific goal of the LAC is at the heart of a deeper understanding of the interactions between solid earth, atmosphere, hydrosphere, and biosphere with a focus on Latin America. The forcing factors governing the Earth's systems also involve the interaction with humankind. In this regard, the modern Earth System Science approach featured at the LAC follows von Humboldt's approach by substituting isolated research efforts with a conference format that fosters a systemic analysis of the Earth's systems. Indeed, already in the early 18th century Alexander von Humboldt recognized the importance of understanding the role of different geoprocesses on the environment and human habitats and vice versa. In this context, understanding the behaviour of the System Earth on geological and shorter time scales remains an ever important topic in the geosciences and is the very objective of the Geosciences at the Universität Hamburg. Following the 15th LAC held at the Universität Hamburg in 1996, the Universität is prepared to host the 25th LAC from September 18 – 21, 2019.

Ulrich Riller & LAC 2019 Scientific Committee

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The venue

Getting to the venue

You may plan your trip using the Hamburg public transport website www.geofox.hvv.de.

From the airport

Take the S-Bahn line S1 to the station “Ohlsdorf” and change to the U-Bahn line U1 towards “Farmsen”. At the station “Kellinghusenstraße”, change to U-Bahn line U3 towards “Hauptbahnhof Süd – Wandsbek-Gartenstadt“ and exit at station “Schlump”. Then, follow on foot the streets “Beim Schlump” and “Bundesstraße” for about 400 m until you reach the Geomatikum.

By train

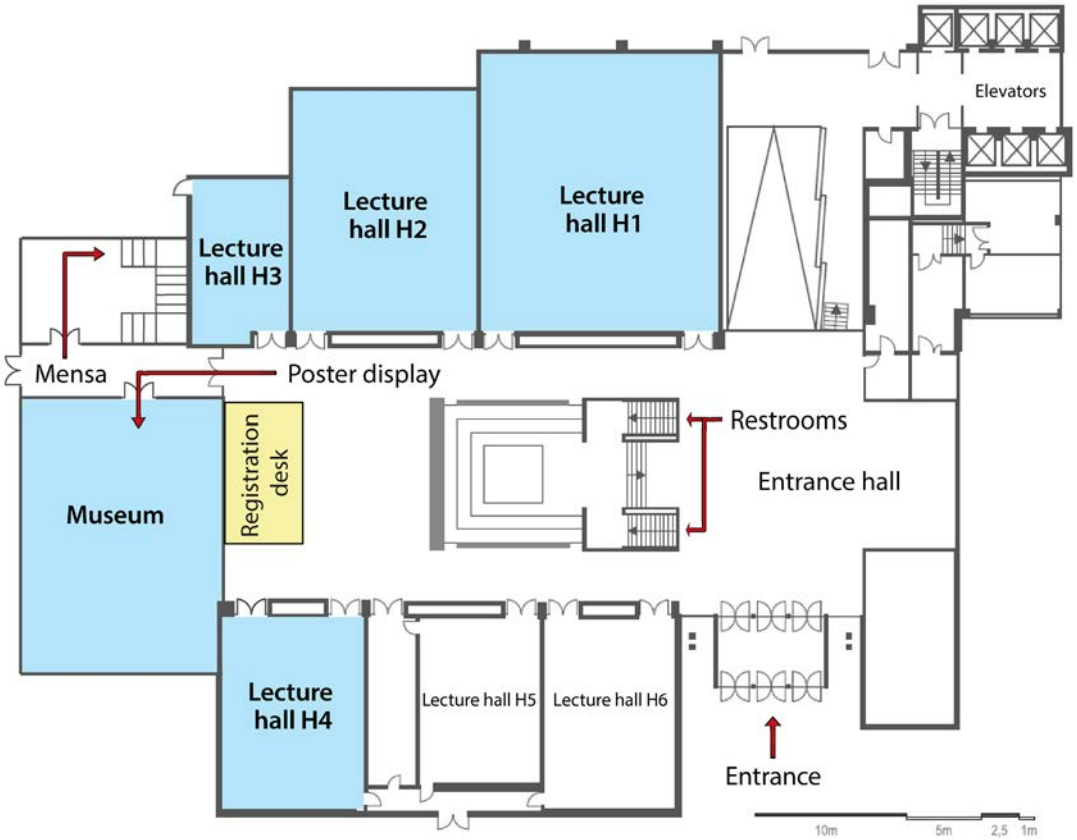
After arriving at the main train station (“Hauptbahnhof”), you may use the U-Bahn line U2 towards “Niendorf Nord” or the U-Bahn line U3 towards “Barmbek – Wandsbek-Gartenstadt”, and exit at station “Schlump”. Then, follow on foot the streets “Beim Schlump” and “Bundesstraße” for about 400 m until you reach the Geomatikum.

By car

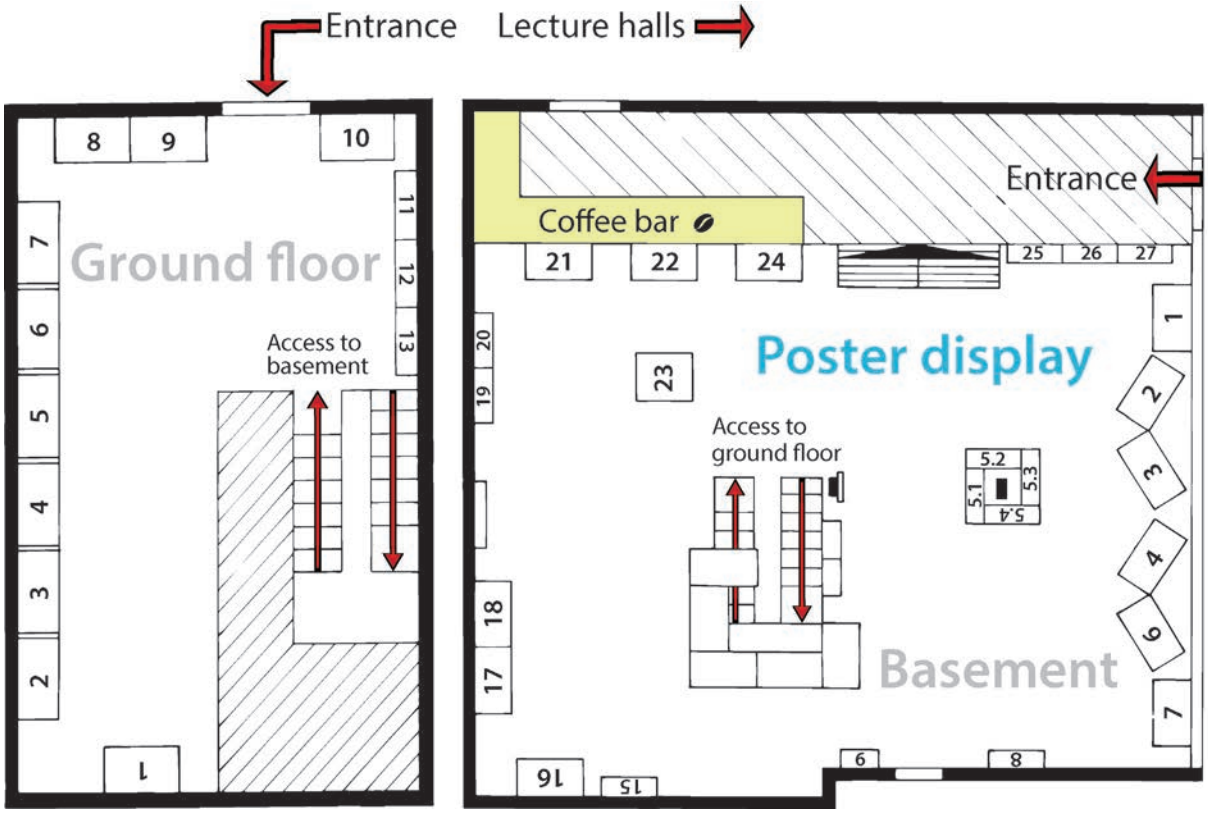
Using the car is not advisable as there is no designated parking area for visitors of the Geomatikum, and public parking space in the vicinity of the building is rather limited.

The conference will be held at the Geomatikum and the Geological and Paleontological Museum of the Universität Hamburg (Bundesstraße 55, 20146 Hamburg, Germany). Oral presentations are delivered in lecture halls H1, H2 and H3. The evening lecture on September 19 will be held in lecture hall H1. Posters are presented in the Museum of Geology and Paleontology. Lunch is available at the Mensa in the Geomatikum (payment in cash only), which offers a vegetarian dish and a salad bar besides regular meals, or at restaurants on the nearby Grindelallee and Beim Schlump (see map).

Floor plan of the Geomatikum



Floor plan of the Geological and Paleontological Museum



Presentation formats

Keynote oral presentations are 30 minutes long and standard talks are 20 minutes long. The duration of both should leave 5 minutes for questions, discussion and change-over to the next speaker. Presenters of oral presentations are kindly asked to ensure that their presentations are uploaded on the computer in the front of the respective lecture hall well in advance to the beginning of the respective session block, which the presentations are scheduled for. A lecture room assistant will help uploading the presentations. We accept PowerPoint files and PDFs. Please refrain from using your own laptop for oral presentations.

In order to provide ample room for discussion of poster presentations, the posters will be displayed in two groups, one on September 19 (day 1) and the other on September 20 (day 2). Each day, a two-hour long poster session will be held in the afternoon. Please refer to the poster session program to identify the day your poster should be on display. The program also indicates the numbers of the poster boards the posters are assigned to. Poster format is A0 portrait (vertical). The scientific and visual quality of young scientist's posters will be assessed by a committee and there will be three poster awards bestowed at the conference dinner.

Scientific Program

September 18, 2019
05:00 p.m. to 09:00 p.m.: Registration and icebraker reception at the Geomatikum

September 19, 2019
08:30 a.m. – 09:15 a.m.: Welcome address
09:20 a.m. – 10:30 a.m.: Oral sessions in lecture halls H2, H3 and H4
10:30 a.m. – 11:00 a.m.: Coffee break
11:00 a.m. – 12:30 p.m.: Oral sessions in lecture halls H2, H3 and H4
12:30 p.m. – 01:30 p.m.: Lunch break
01:30 p.m. – 03:20 p.m.: Oral sessions in lecture halls H2 and H4
03:20 p.m. – 05:30 p.m.: Poster session in the Museum
05:30 p.m. – 06:30 p.m.: Public evening lecture in Lecture hall H1

September 20, 2019
08:30 a.m. – 10:00 a.m.: Oral sessions in lecture halls H2, H3 and H4
10:00 a.m. – 10:30 a.m.: Coffee break
10:30 a.m. – 12:00 a.m.: Oral sessions in lecture halls H2, H3 and H4
12:00 a.m. – 01:30 p.m.: Lunch break
01:30 p.m. – 03:30 p.m.: Oral sessions in lecture halls H2 and H4
03:30 p.m. – 05:30 p.m.: Poster session in the Museum
05:30 p.m. – 06:00 p.m.: Concluding remarks in lecture hall H2
06:00 p.m. – 07:00 p.m.: Break and transfer to the St. Pauli Landungsbrücken
07:00 p.m. – 10:00 p.m.: Conference dinner on the *Rickmer Rickmers*

September 21, 2019
Geological field trips und museum tours

Program: Thursday, 19.09.2019 - morning sessions

	Lecture hall H2		Lecture hall H3		Lecture hall H4
8:30 - 9:15	**Welcome address (Lecture hall H2)**				
	Subduction zone seismotectonics Hosted by IPOC and PICTURES Conveners: H. Kopp, O. Oncken		Conveners: S. Kasemann, G. Schmiedl		Conveners: B. Weber, W. Teixeira
9:20 - 9:50 **Keynote**	Structure and geodynamics of the collision zones of the Nazca and Juan Fernández Ridges with South America **E. Contreras-Reyes**	9:20 - 9:50 **Keynote**	Tipping elements of the climate system and marine sediments: The western tropical Atlantic and the adjacent South America **C. Chiessi**, S. Mulitza, S. Crivellari, C. Häggi, N. Höppner, S. Kasemann, H. Kuhnert, R. Portilho-Ramos, M. Prange, G. Sampaio, A. Sawakuchi, E. Schefuß, I. Voigt, Y. Zhang	9:20 - 9:50 **Keynote**	The Paleoproterozoic Minas Orogen, São Francisco Craton reviewed: insights into an evolving accretionary-collision orogenic system and global implications **W. Teixeira**
9:50 - 10:10	Upper plate stress field in the northern Chile forearc from earthquake source mechanisms **B. Schurr**, L. Lehmann, C. Sippl, W. Bloch	9:50 - 10:10	The sediment archive of the western Campeche Bank: From Chicxulub impact to Loop Current evolution **C. Hübscher**, D. Nürnberg	9:50 - 10:10	Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the SE coastal region of Brazil F. Krob, **U. A. Glasmacher**, M. Karl, M. Perner, P. C. Hackspacher, D. F. Stockli
10:10 - 10:30	3D seismic tomography and seismotectonics of the Ecuadorian margin inferred from the 2016 Mw 7.8 Pedernales aftershock sequence **S. Leon-Rios**, A. Rietbrock, H. Agurto-Detzel, A. Alvarado, A. Meltzer, B. Edwards, C. Lynner, F. Rolandone, J. M. Nocquet, L. Soto-Cordero, M. Regnier, M. Hoskins, M. Ruiz, P. Charvis, S. Beck, Y. Font	10:10 - 10:30	"The present is the key to the past": An actualistic study on the foraminiferal assemblages of Albuquerque Cay (Colombian Caribbean) **G. D. Patarroyo Camargo**, D. F. Gómez González	10:10 - 10:30	Coeval Early Ediacaran Breakup of Amazonia, Baltica, and Laurentia: Evidence for a large igneous province from SIMS U-Pb dating of mafic dykes from Mexico. **B. Weber**, A. Schmitt, A. Cisneros de León, R. González-Guzmán
10:30 – 11:00	**Coffee break (Museum)**				
11:00 - 11:30 **Keynote**	Present Status and Future Plans for the Chilean Seismic Network **S. Barrientos Parras**	11:00 - 11:30 **Keynote**	Upper Cretaceous palaeosols as basin analysis proxies: Bauru group (SE Brazil) and Los Llanos formation (NW Argentina) **G. Basilici**, M. V. Soares Theodoro , F. R. Abrantes Júnior, A. Cardoso Ribeiro	11:10 - 11:30	Uranium zonation refined U-Pb thermochronology – application to the Northern Andes of South America **A. Paul**, R. A. Spikings, D. Chew, S. J. Daly
11:30 - 11:50	Structure of and dynamic processes within the crust of Northern Chile (IPOC area) based on ambient seismic noise correlations and repeating Earthquakes C. Sens-Schönfelder, **F. Tilmann**, B. Heit, R. Green	11:30 - 11:50	Autogenic controls on the distribution of sediments and palaeosols in ancient distributive fluvial systems (Bauru basin, Brazil) **M. V. Theodoro Soares**, G. Basilici, T. da Silva Marinho , A. Guillermo Martinelli, A. Marconato, F. Romério Abrantes Júnior, R. Vásconez Garcia	11:30 - 11:50	Extension of the Ordovician pre-Andean Famatinian arc in northeastern Mexico: Peregrina tonalite **J. A. Ramirez-Fernandez**, E. A. Alemán-Gallardo, F. Velasco-Tapia, U. Jenchen, R. Becchio
11:50 - 12:10	Filling the gap in a double seismic zone: Intraslab seismicity in Northern Chile **C. Sippl**, B. Schurr, T. John, S. Hainzl	11:50 - 12:10	Evidences of early Holocene glacial advance in Lachman Beach, James Ross Island, Antarctica; and high latitude linkages in southern hemisphere **M. Romero**, J. A. Strelin, M. R. Kaplan	11:50 - 12:10	PTt-paths of high pressure metamorphic rocks in the Sierra Pie Palo (W-Argentina): evolution of a flat collisional wedge during a "hard" continent-arc collision **A. Willner**, R. Anczkiewicz,, J. Glodny, J. Pohlner, M. Sudo, C. R. van Staal, G. Vujovich
12:10 - 12:30	The Central Andean double seismic zone: seismological constraints on the processes within **W. Bloch**, T. John, J. Kummerow, B. Schurr, P. Salazar, P. Wigger, S. A. Shapiro	12:10 - 12:30	Evidences of permafrost degradation in the Arid Andes and its potential effect on hydrological resources **J. P. Milana**, L. Schrott, S. Wohnlich	12:10 - 12:30	Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the Argentine passive continental margin **U. A. Glasmacher**, S. Kollenz, E. A. Rossello, D. F. Stockli, R. E. Pereyra

Program: Thursday, 19.09.2019 - afternoon sessions

12:30 - 13:30	**Lunch break**	
	Lecture hall H2	**Lecture hall H4**
	Subduction earthquake dynamics Hosted by IPOC and PICTURES Conveners: B. Schurr, D. Lange	**Crustal evolution of ancient terranes** Conveners: B. Weber, W. Teixeira
13:30 - 14:00 **Keynote**	Understanding seismic and tsunami hazards in the Chilean subduction zone: lessons and perspectives from the framework of interdisciplinary studies **G. González L.**	
14:00 - 14:20	Unveiling giant tsunamigenic earthquakes along the hyperarid Atacama Desert in the major Northern Chile Seismic Gap at multimillennial timescales **G. Vargas**, D. Salazar, J. Goff	3D density structure of the Caribbean lithosphere derived from Vertical Gravity Gradients: Implications for regional tectonic boundaries and the characterisation of geohazards **Á. M. Gómez García**, C. Meeßen, M. Scheck-Wenderoth, Á. González, G. Monsalve, J. Bott, A. Bernhardt, G. Bernal
14:20 - 14:40	Multi-Array Back-Projection: Rupture complexities due to asperities along-dip barriers during the 2007 Mw 7.7 Tocopilla earthquake **F. Vera**, F. Tilmann, J. Saul	Paleomagnetism of Middle-Late Jurassic Bahía Laura Group (Patagonia, southern Argentina) **V. Ruiz González**, C. G. Puigdomenech, E. M. Renda, B. Boltshauser, C. B. Zaffarana, H. Vizán
14:40 - 15:00	Earthquake scaling models applied to seismicity analysis in Chile **C. Siegel**, J. Campos, B. Derode, P. Toledo	14:40 – 15:00 Regional depocenter geometry and subsurface frontal structural features in the foothills and western foreland llanos Sub-Andean basin (Colombia) based on gravimetric modeling **P. N. Morales Hernandez**, A. Kammer, J. C. Alzate, M. Garcia
15:00 - 15:20	Role of Continental Lower Crust Following the 2010 Mw 8.8 Maule Earthquake: Insights from a Power-Law Rheology Model with Dislocation Creep **C. Peña**, O. Heidbach, M. Moreno, J. Bedford, M. Ziegler, A. Tassara, O. Oncken	
15:20 - 17:30	**Coffee & posters day 1 (Museum)**	
17:30 - 18:30	**Evening lecture (Lecture hall H1)**	

Program: Friday, 20.09.2019 - morning sessions

Lecture hall H2

Climate and erosion in the Andes

Hosted by IRTG-StRATEGy

Conveners: M. Scheck-Wenderoth, M. Strecker

8:30 - 9:00 **Keynote**	Paleoclimate reconstructions from fluvial sedimentary deposits in an intermontane basin in the southern Central Andes - A case study from the Quebrada del Toro, NW Argentina **S. Tofelde**, T. Schildgen, M. Strecker, B. Bookhagen, A. Wickert, S. Savi, H. Pingel, H. Wittmann, R. Alonso
9:00 - 9:20	Paleoclimate, Paleoenvironment, and Paleoecology of Neogene Central America: Bridging Continents and Oceans (NICA-BRIDGE) **S. Kutterolf**, M. Brenner, A. Freundt, J. Kallmeyer, S. Krastel, S. Katsev, A. Meyer, L. Pérez, J. Rausch, A. Saballos, A. Schwalb, W. Strauch
9:20 - 9:40	Deciphering a steep erosional gradient in the hyperarid core of the Atacama Desert, northern Chile **J. Mohren**, S. A. Binnie, B. Ritter, D. A. Lopez, T. J. Dunai
9:40 - 10:00	Impacts of climate and humans on vegetation in northeastern Brazil during the late Holocene **C. Alves de Moraes**, H. Behling, M. Accioly Teixeira de Oliveira

Lecture hall H3

Volcanism and tectonics

Conveners: J. Behrmann, M. Rosenau

8:30 - 9:00 **Keynote**	The Central and Southern Volcanic Zones of the Andes, what we know and what we do not know **I. Petrinovic**
9:00 - 9:20	The Quaternary Payún Matrú caldera, andean back-arc of the Southern Volcanic Zone: insights into its caldera-forming eruption deposits **I. Hernando**, I. Petrinovic, D. Gutiérrez, J. Bucher, T. Fuentes, E. Aragón
9:20 - 9:40	Distributed transpressive deformation in the Southern Andes: Insights from low-temperature geochronology and DEM-analysis **P. Göllner**, J. O. Eisermann, U. Riller
9:40 - 10:00	Volcano-tectonic analysis at the northern terminus of the Liquiñe-Ofqui Fault Zone (38°S): The Copahue Volcano, Argentina **E. Pitzke**, P. Göllner, J. O. Eisermann, I. Petrinovic, U. Riller

Lecture hall H4

Subduction earthquake dynamics

Hosted by IPOC and PICTURES

Conveners: B. Schurr, D. Lange

8:30 - 9:00 **Keynote**	Seismic imaging of the source region of great megathrust earthquakes offshore Chile: an overview of recent results **A. Tréhu**
9:00 - 9:20	Slab hydration: combining constraints from oceanic plate structure and intraslab seismicity **J. Geersen**, C. Sippl
9:20 - 9:40	Instrumental monitoring of shallow slip events on active faults reveals the ability of velocity weakening behaviour at shallow crustal levels **P. Victor**, A. Müting, G. González L., O. Oncken
9:40 - 10:00	Seafloor geodesy to monitor deformation offshore Northern Chile (GeoSEA) **D. Lange**, H. Kopp, K. Hannemann, F. Petersen, J. Bedford, S. Barrientos, E. Contreras-Reyes

10:00 - 10:30 **Coffee break (Museum)**

Lecture hall H2

Mountain building and deformation in the Andes

Hosted by IRTG-StRATEGy

Conveners: M. Scheck-Wenderoth, M. Strecker

10:30 - 11:00 **Keynote**	Interplay between constructive deep mechanisms building the Central Andes and the stress field **L. Giambiagi**, S. Spagnotto, A. Tassara, J. Suriano, J. Mescua, A. Lossada, M. Barrionuevo, J. Julve
11:00 - 11:20	Deformation and rheology of the Central Andean lithosphere F. Ibarra, **C. B. Prezzi**, M. L. Gómez Dacal, M. Scheck-Wenderoth, J. Bott, M. Strecker
11:20 - 11:40	Regional transect across the Quirquincho Arch (NW Argentina) **V. Cortassa**, E. A. Rossello, S. Back, R. Ondrak, M. Strecker
11:40 - 12:00	Full crustal scale deformation structures in the Central Andean Foreland revealed by recent seismotectonic activity. **M. Zeckra**, G. Aranda Viana, E. J. M. Sutti Criado, A. Arnous, F. Krüger, M. Strecker, F. Hongn

Lecture hall H3

Volcanism and tectonics

Conveners: J. Behrmann, M. Rosenau

10:40 - 11:00	Processes culminating in the 2015 phreatic explosion at Lascar volcano, Chile, monitored by multiparametric data **A. Gaete**, T. Walter, S. Bredemeyer, M. Zimmer, C. Kujawa, L. Franco, J. San Martin, C. Bucarey Parra
11:00 - 11:20	Hydro-geothermal Circulation Systems in the Central Andes of Argentina – The Example of Pismanta **S. Wohnlich**, J. Schreuer, I. Hinzer, M. Altherr, I. Sass, R. Schäffer
11:20 - 11:40	Structural control on carbon dioxide diffuse degassing at the Caviahue – Copahue Volcanic Complex, Argentina **M. C. Lamberti**, N. Vigide, S. Venturi, M. Agusto, D. Yagupsky, D. Winocur, H. Barcelona, M. L. Vélez, F. Tassi

Lecture hall H4

Natural resources

Hosted by Wintershall-DEA

Conveners: M. Mohr, N. Buurman

10:40 - 11:00	Multistage evolution of a Neoproterozoic quartz-gold vein mineralization, Dom Feliciano orogenic belt, Uruguay **G. Sosa**, A. Van den Kerkhof, K. Wemmer, F. Paullier, J. Spoturno, P. Oyhantçabal
11:00 - 11:20	Bacterially reduced sulfur in organic-rich facies of early Eocene red-beds (Cuzco region, Peru) as trap for copper during migration of basinal fluids **S. Rosas**
11:20 - 11:40	Hydrogeochemistry and origin of elevated concentrations of fluoride, arsenic and uranium in the area of the San Antonio el Grande mine, Chihuahua / Mexico **D. Schwertfeger**, A. Cardona Benavides, S. Alonso Torres, A. Banning
11:40 - 12:00	Mapping marine geothermal resources with the magnetotelluric method in the northern Gulf of California **T. A. Avilés-Esquivel**, C. Flores-Luna, V. Reyes-Ortega, E. Gómez-Treviño, S. Constable, G.-F. Antonio

Program: Friday, 20.09.2019 - afternoon sessions

12:00 - 13:30	**Lunch break**	
	Lecture hall H2	**Lecture hall H4**
	Mountain building and deformation in the Andes Hosted by IRTG-StRATEGy Conveners: M. Scheck-Wenderoth, M. Strecker	**Natural resources** Hosted by Wintershall-DEA Conveners: Conveners: M. Mohr, N. Buurman
13:30 - 14:00 **Keynote**	Andean exhumation and erosion across the Pampean flat-slab transition **G. Hoke**, A. Lossada, P. Val, L. Giambiagi	Early evolution of the Gulf of Mexico: Synrift successions, climate, and tectonic setting **R. S. Molina-Garza**, J. Pindell, T. F. Lawton
14:00 - 14:20	Crustal deformation and loading effects in southern Patagonia **E. Marderwald**, A. Richter, L. Mendoza, J. L. Hormaechea, R. Perdomo, A. Groh, M. Horwath, J. M. Aragon Paz, P. Busch, M. Scheinert, M. Kappelsberger, R. Dietrich	Palynofacies and maturity offshore Suriname – implications for the petroleum system **B. Holstein**, B. Boeckel
14:20 - 14:40	Lithospheric temperature and rheology of the North Patagonian Massif plateau, Argentina. **M. L. Gomez Dacal**, M. Scheck-Wenderoth, M. Cacace, E. Aragón, C. Tocho	Interplay between salt tectonics and gravitational extension tectonics in the Sureste Basin, Mexico **M. Giba**, M. Mohr, C. Schneider
14:40 - 15:00	Structure of the Argentine passive volcanic continental margin from 3D gravity modelling and isostatic calculations **C. Prezzi**, M. A. Arecco, F. Ruiz	Carbonate Reservoirs of Brazilian Pre-salt **A. Vidal**
15:00 - 15:30 **Keynote**		Deformation and differential subsidence in the Neuquén Basin, outlines for hydrocarbon exploration **E. Cristallini**, R. Tomezzoli, M. Mazzoni, C. Guzmán, N. Hernández
15:30 - 17:30	**Coffee & posters day 2 (Museum)**	
17:30 - 18:00	**Concluding remarks (Lecture hall H2)**	
18:00 –. 19:00	Break and transfer to the St. Pauli Landungsbrücken (Port of Hamburg)	
19:00 - 22:00	**Conference dinner (*Rickmer Rickmers*)**	

Poster sessions day 1, Thursday 19.09.2019, 15:20h – 17:30h

Poster board number	Subduction zone seismotectonics and earthquake dynamics
1	Full-Waveform Inversion for Seismic Velocity and Moment Tensor Solutions beneath North Chile **Y. Gao**, F. Tilmann, D.-P. van Herwaarden, S. Thrastarson, A. Fichtner
2	Rupture directivity and stress drop estimation at the Northern Chilean subduction zone **J. Folesky**, J. Rakau, J. Kummerow, S. A. Shapiro
3	Seismic structure and tectonics of the north Chilean convergent margin between 19ºS and 21ºS using multichannel seismic reflection data **F. Gonzalez**, E. Contreras, A. Tréhu, E. Vera
4	Electrical structure of the Andean orogenic crust in Northern Chile at 23°S using magnetotelluric data **F. Reyes Córdova**, D. Díaz Alvarado, K. Slezak
5	Seismic Processing Strategy and Crustal Structure of the April 1, 2014 Mw 8.2 Rupture Area Offshore Northern Chile from Seismic Reflection Data **B. Ma**, D. Kläschen, H. Kopp, A. Tréhu
6	Marine forearc structure of the 2014 Mw 8.1 Iquique earthquake revealed by hypocenter locations from offshore observations **F. Petersen**, D. Lange, I. Grevemeyer, H. Kopp, E. Contreras-Reyes, S. Barrientos
7	Kinematics of subduction processes during the earthquake cycle in Central Chile **K. Bataille**, L. Aguirre, C. Novoa, C. Peña, F. Vera
8	Subduction kinematics in the years before and after the 2014, Iquique Mw 8.1 Earthquake, Chile from de-noised GPS trajectories and joint slip-strain models **J. Bedford**, Z. Deng, M. Moreno, D. Lange, B. Schurr, H. Soto
9	Probing the Northern Chile megathrust with seismicity – The 2014 M8.1 Iquique earthquake sequence **H. Soto**, C. Sippl, B. Schurr, J. Kummerow, G. Asch, F. Tilmann, D. Comte, S. Ruiz, O. Oncken
	Crustal evolution of ancient crustal terranes
10	P-T-d path of a garnet-bearing metagranite from the Paleoproterozoic basement of the Tandilia terrane, Rio de la Plata craton, Argentina **M. Angeletti**, J. C. Martínez, M. C. Frisicale, H.-J. Massonne
11	Thermochronology of the São Francisco Craton and Araçuaí-Ribeira Orogenic System Transition A. O. Chaves, L. G. Knauer, A. W. Romano, **B. A. Alemao Monteiro**, A. L. Ximenes, C. E. Vieira, G. B. Vargas, C. Lana, M. Silva, A. R. Alkimin
12	The Iglesias Complex in the Merida Andes Venezuela: A record of Cambrian-Silurian continental arc and Permo-Triassic Pangea amalgamation in western Gondwana **M. D. Tazzo**, B. Weber, A. Schmitt, R. González-Guzmán, V. Valencia, D. Frei, P. Schaaf, L. Solari
	Volcanism and tectonics
13	Tortonian trachyte volcanoe in the Alta Sierra de Somún Curá Volcanic Complex. Northern Extrandean. Patagonia. Argentina **M. Remesal**, M. E. Cerredo, J. M. Albite, F. Salani, C. Parica
14	Somún Curá Magmatic Province (Argentina). Lava-pyroclastic sequence southern of El Cain village: Age and composition **F. Salani**, M. Remesal, M. E. Cerredo, C. Parica
15	2D modelling of magnetic anomaly Tona on the Argentine continental margin **A. C. Pedraza De Marchi**, M. E. Ghidella, J. R. Franzese
16	Geothermal systems exploration in the southern Chilean volcanic zone by magnetotelluric method **M. Pavez**, E. Schill, S. Held, D. Díaz, T. Kohl
17	Advances in B isotope analysis of silicate rocks – applications in arc settings (Chile) **A. Paul**, L. A. Kirstein, I. Savov, C. de Hoog, T. Elliott, S. J. Turner, S. Agostini
18	Investigation of fractal dimensions of impact-induced cataclasite of the Chicxulub impact crater based on an improved semi-automatic image segmentation workflow using SAGA GIS **S. Kölln**, O. Conrad, U. Riller
19	Tracing the volcanic and tectonic effects of the Miocene Andean stage along the Patagonian retroarc: an example of the Río Negro system, Argentina **L. D'Elia**, A. Bilmes, M. López, J. Bucher, M. García, R. Feo, J. Cuitiño, J. R. Franzese

Poster sessions day 1, Thursday 19.09.2019, 15:20h – 17:30h

20	Dynamic interaction of the initial impact melt sheet during peak-ring formation of the Chicxulub Impact Crater, México **F. Schulte**, U. Riller
21	Miocene volcaniclastic foreland basin infill next to the exhumed North Patagonian Andean batholith: a record of collapse-caldera eruptions? **M. López**, J. Bucher, M. García, L. D`Elia, A. Bilmes, J. Franzese
22	Holocene flank-eruptions at the Lanín Volcano (Southern Volcanic Zone), Patagonia C. Balbis, **I. A. Petrinovic**, J. A. Brod
23	Geodynamic importance of the spatial distribution of monogenetic volcanic centers in the Southern Andes between 39°S and 37°S **Y. Lee**, P. Göllner, U. Riller
	Ocean, sediment, and climate dynamics
24	A late Quaternary paleoecological record from Lake Petén Itzá, Guatemala: effects of abrupt climate change on aquatic and terrestrial communities in the lowland northern Neotropics **L. Pérez**, A. Correa-Metrio, S. Cohuo, L. Macario-Gonzalez, M. Brenner, S. Kutterolf, M. Stockhecke, A. Schwalb
25	Basin evolution, lake establishment and orbital scale climatic variability: the ca. 500 ka sedimentary record of Lake Chalco, central Mexico **B. Ortega**, R. Martínez, L. Romero, D. Avendaño, S. Lozano, M. Caballero, E. Brown, B. Valero, M. Stockhecke, P. Fawcett, J. Werne, L. Pérez, A. Schwalb
26	Tracking changes in weathering influx into late Ediacaran marine systems using lithium isotopes in carbonate rocks: An example from the Corumbá Group, Brazil **G. Paula-Santos**, S. Kasemann, A. Meixner, S. Caetano-Filho, R. Trindade, K. Amorim, J. Enzweiler
27	Reconstructing past climatic changes using lacustrine sediments from Laguna Comedero, NW Argentina **P. Vignoni**, R. Tjallingii, F. Córdoba, B. Plessen, G. Torres, L. Lupo, A. Brauer
28	Palaeoenvironmental changes over the last millennia in the subtropical forests of Northwest Argentina inferred from fossil pollen records **G. Torres**, L. Lupo, P. Vignoni, F. Córdoba, A. Brauer
29	Water table and biotic effects on Precambrian aeolian depositional systems in Brazil and India **G. Basilici**, F. R. Abrantes Júnior, M. V. Soares Theodoro, A. Cardoso Ribeiro, R. Vásconez Garcia
30	Future offshore research activities in Northern Chile using RV SONNE **H. Kopp**, D. Lange
31	Strontium isotope dating of evaporites and the breakup of the Gulf of Mexico and Proto-Caribbean seaways **B. Weber**, J. Pindell, S. Padilla-Ramírez
	Geophysics
32	GPR supported sampling for environmental purposes. Examples from te Rio São Francisco marginal lagoons, Minas Gerais, Brazil **H. A. Horn**, P. A. Aranha, W. Trindade, A. Magalhães
33	Urban micro-gravity: study of irregularities in the basement of Querétaro city (Mexico) and subsidence risks **V. Yutsis**, J. A. Arzate Flores, D. A. Velásquez, A. Días de León, D. E. Torres, M. Espinosa
34	Towards Visualization Possible Fluid Pathways Using Gravity in the Los Humeros and Acoculco Geothermal Fields **N. Cornejo**, E. Schill, S. Held, J. Carrillo, M. Pérez

Poster sessions day 2, Friday 20.09.2019, 15:30h – 17:30h

Poster board number	Deformation, climate, and erosion in the Andes
1	The Paleozoic Claromecó Basin (Argentina): 3D lithospheric scale density model **S. E. Vazquez Lucero**, C. Prezzi, M. Scheck-Wenderoth, J. Bott, M. L. Gomez Dacal, H. Vizan, F. I. Ballestrini
2	Tectonic and climatic coupled processes in North Patagonian Andes: Miocene orographic barrier uplift and rain shadow generation **J. Bucher**, A. Bilmes, L. D'Elia, M. López, M. García, A. Varela, J. Franzese
3	GNSS-based remote sensing: Innovative observation of key hydrological parameters in the Central Andes **N. Antonoglou**, B. Bookhagen, J. Wickert, A. Güntner, A. de laTorre
4	The role of mass wasting in glacial forelands of the Andes **E. Schönfeldt**, O. Korup, D. Winocur, T. Pánek
5	Approaching the organic carbon balance: Interaction of climate, tectonics, erosion and biota in riverine carbon transport and respiration at the Bermejo River **S. Dosch**, N. Hovius, D. Sachse
6	New insights about South American hydroclimate changes during Heinrich Stadials **M. C. Campos**, C. M. Chiessi, M. Prange, S. Mulitza, H. Kuhnert, A. Paul, I. M. Venancio, A. L. S. Albuquerque, F. W. Cruz, A. Bahr
7	The Miocene foreland basins of Northern Patagonia: sediment transfer systems from the Southern Andean to the Atlantic shelf **A. Bilmes**, L. D'Elia, J. Cuitiño, J. Bucher, M. López, M. García, R. Feo, J. Franzese
8	Testing long-term controls of sedimentary basin architecture in the broken foreland II – Modelling the spatial variability of the strata **M. Vallati**, M. Mutti, G. Winterleitner
9	Insights on the late Cenozoic evolution of the Rio Grande foreland basin in South Mendoza province, Argentina **R. Feal**, M. Ghiglione, R. Ondrak, M. Strecker, F. Tapia, L. Giambiagi
10	Stratigraphic architecture in early stages of intermontane basin: the Miocene Calchaquí foreland, NW Argentina **C. E. del Papa**, P. Payrola, F. Hongn, H. Pingel, M. Do Campo, A. Lapiana, M. R. Strecker
11	Kinematically heterogeneous faulting in the configuration of Neogene Patagonian foreland basins: activation of pre-existing fabrics and strain partitioning **M. Garcia**, M. Lopez, J. Bucher, L. D'Elia, A. Bilmes, J. Franzese
12	Along-strike crustal strength gradient accounts for the GPS velocity field in the Southern Andes: evidence from scaled analogue experiments **J. O. Eisermann**, P. L. Göllner, U. Riller
13	The nature of the North-South change of the magnitude of tectonic shortening in Central Andes at Altiplano-Puna latitudes: a thermomechanical modeling approach **P. Michael**, S. Sobolev, S. Liu
14	Insights on the lithospheric density structure of the Southern Central Andes and their foreland **C. Rodriguez Piceda**, M. Scheck-Wenderoth, M. L. Gomez Dacal, J. Bott, C. Prezzi, M. Strecker
15	Late Pleistocene to Recent shortening rates in the broken foreland of NW Argentina: New observations from the intermontane Cafayate Valley, 26° S lat. **S. Figueroa**, J. Weiss, F. Hongn, L. Elias, L. Escalante, G. Aranda, M. R. Strecker
16	Quaternary deformation at the Lerma Valley, Northwestern Argentina L. I. Elías, **C. Montero Lopez**, E. J. Criado Sutti, V. H. García, F. Hongn, F. Krüger, M. Strecker
17	Exhumation history of the Argentine eastern cordillera at 23°s **A. T. Lapiana**, E. Sobel, C. del Papa, C. Montero-López, S. Zapata
18	Neotectonics of the Andean Plateau (Puna) **G. Lauer-Dünkelberg**

Poster sessions day 2, Friday 20.09.2019, 15:30h – 17:30h

	Natural resources
19	Multi-physics Inversion of Gravity and Magnetic Data in Los Humeros Super Hot Geothermal System, México **J. Carrillo Lopez**, M. A. Perez-Flores, E. Schill
20	Lithium sources in northern Puna salars, Argentina. Evidence from Li and Sr isotope compositions **C. Sarchi**, A. Meixner, F. Lucassen, P. J. Caffe, R. Becchio, S. A. Kasemann
21	Constraining the magmatic-hydrothermal fluid evolution from proximal to distal settings by fluid inclusion and isotopic analyses of ore and gangue minerals and numerical modelling **M. Stoltnow**, V. Lüders, P. Weis, R. L. Romer
22	Water chemistry in Somún Cura region, Rio Negro and Chubut Provinces, Argentina **C. Parica**, M. Remesal
23	Isotopic (Nd-Sr-Pb) signature of the diamictitic iron formations from the Neoproterozoic Macaúbas Group, Araçuaí orogen, SE Brazil **F. Vilela**, A. C. Pedrosa Soares, F. Lucassen, S. Kasemann
24	Fluid inclusion and stable isotope geochemistry of rare-metal pegmatites, Sierra Grande de San Luis, Argentina **A. van den Kerkhof**, G. Sosa, V. Lüders, T. Montenegro
25	LCT and NYF pegmatites as an indicator for the magmatic evolution of the Las Chacras Batholith, central Argentina **E. Ribacki**, U. Altenberger, R. Trumbull, M. Lopez de Luchi
26	First qualitative observations and interpretation of fluid and melt inclusions from Capoeirana and Nova Era emerald deposits, Minas Gerais, Brazil **I. Pintea**, H. A. Horn
27	Presence of critical metals (Sc and REE) in laterites from ophiolitic Moa-Baracoa complex, Cuba. An investiment opportunity for EU? **G. Orozco**, A. Carballo, J. N. Muñoz
	Other topics
28	Metal accumulation in surface sediment of the urban and industrial coastal area of the municipality of Moa (Cuba): distribution and pollution assessment **Y. Cervantes Guerra**, H.-J. Gursky, A. Rodríguez, A. Pierra
29	Dam Collapse: the case of Brumadinho – 2019 (Brumadinho, Minas Gerais – Brazil) **J. Oliveira**, P. W. Oliveira
30	The new binational Argentinian-German master's program "Applied Geothermics" (San Juan/Bochum) **S. Wohnlich**, N. Mendoza, J. Schreuer, A. Banning, C. G. Fernandez, M. A. Pittaluga
31	Geologic recognition of the Eocene Los Corros fossiliferous level (Esmeraldas formation, middle Magdalena valley, Colombia) L. J. Ordoñez, **G. D. Patarroyo Camargo**
32	Analysis of diversification histories in extinct carnivorous marsupials (Sparassodonta, Metatheria) using a Bayesian framework **S. Tarquini**, S. Ladevèze, F. Prevosti

Invited keynote speakers

Prof. Dr. Wilson Teixeira (Universidade de São Paulo, Brazil)
Prof. Dr. Gabriel González (Universidad Católica del Norte, Antofagasta, Chile)
Prof. Dr. Sergio Eduardo Barrientos (Universidad de Chile, Santiago, Chile)
Prof. Dr. Anne Tréhu (Oregon State University, USA)
Prof. Dr. Eduardo E. Contreras-Reyes (Universidad de Chile, Santiago, Chile)
Prof. Dr. Laura Giambiagi (CONICET, Mendoza, Argentina)
Dr. Stefanie Tofelde (Institut für Geoökologie, Universität Potsdam)
Prof. Dr. Giorgio Basilici (State University of Campinas, Brazil)
Prof. Dr. Ivan Petrinovic (CICTERRA Córdoba, Argentina)
Prof. Dr. Ernesto Cristallini (Universidad de Buenos Aires, Argentina)
Prof. Dr. Roberto S. Molina-Garza (UNAM, Mexico City, Mexico)
Prof. Dr. Cristiano Mazur Chiessi (Universidad de Sao Paulo, Brazil)
Prof. Dr. Gregory Hoke (Syracuse University, USA)

Travel grant recipients

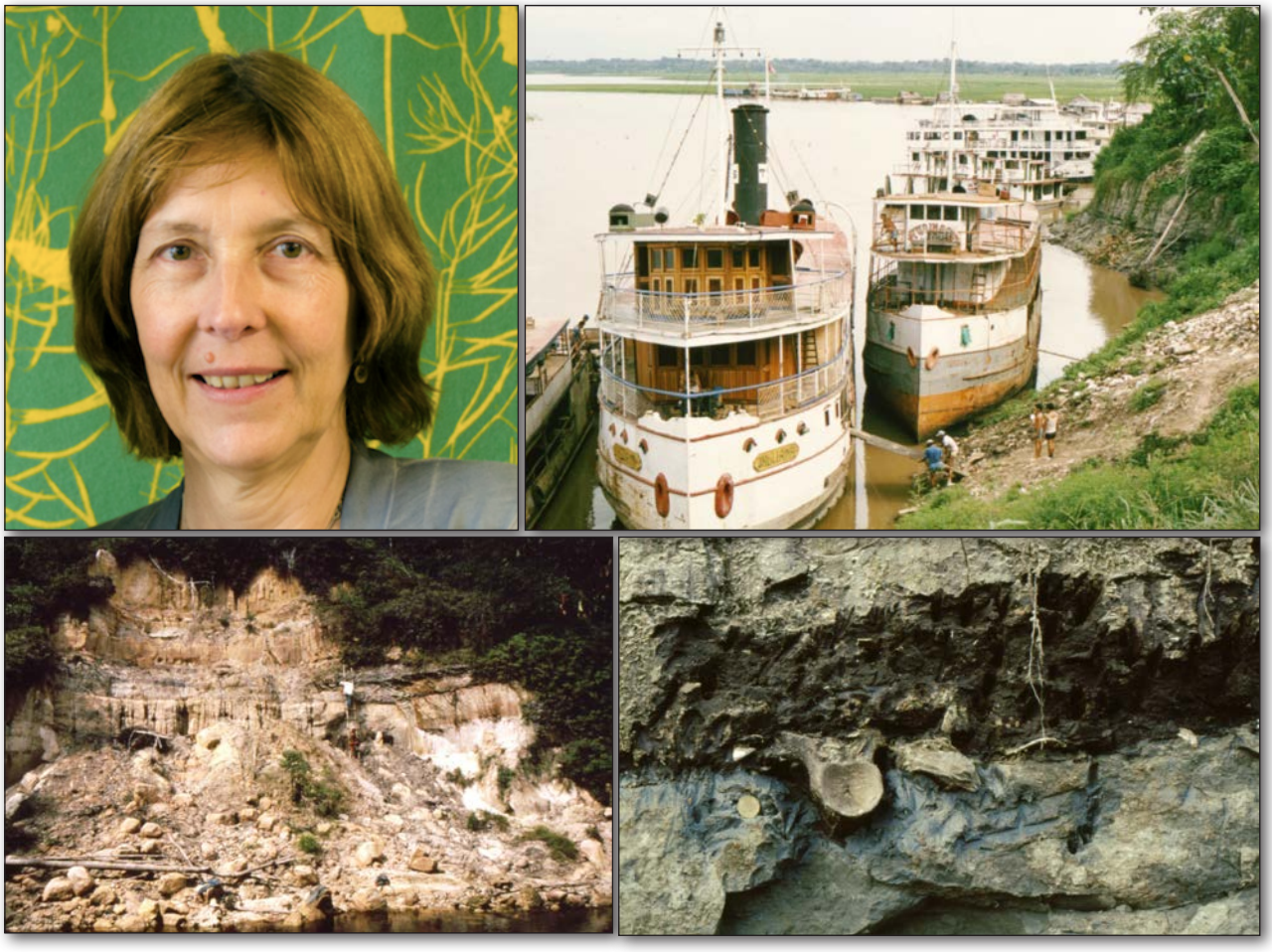
Bruno Augusto Alemão Monteiro (Universidade Federal de Minas Gerais, Brazil)
Marcus Vinícius Theodoro Soares (State University of Campinas, Brazil)
Marília C. Campos (Universidade de São Paulo, Brazil)
German David Patarroyo (Universidad Industrial de Santander, Colombia)
Felipe Gonzalez Rojas (Universidad de Chile, Santiago, Chile)
Cristián Eduardo Siegel Ignatiew (Universidad de Chile, Santiago, Chile)
Felipe Reyes Córdova (Universidad de Chile, Santiago, Chile)
Dr. Andrés Bilmes (CENPAT-CONICET, Puerto Madryn, Argentina)
Lic. Sergio Daniel Tarquini (CONICET, Mendoza, Argentina)
Eric Marderwald (CONICET, National University of La Plata, Argentina)
Dr. María Clara Lamberti (University of Buenos Aires, Argentina)
Lic. Carisa Sarchi (INECOA-CONICET, S.S. de Jujuy, Argentina)
Dr. Irene R. Hernando (CONICET, National University of La Plata, Argentina)
Matias Romero (CICTERRA, Cordoba, Argentina)
Manuel López (CONICET, National University of La Plata, Argentina)
Dr. Joaquín Bucher (CONICET, National University of La Plata, Argentina)
Víctor Ruiz González (CONICET, University of Buenos Aires, Argentina)
Micaela García (National University of La Plata, Argentina)
Thalia Anaid Avilés Esquivel (Ensenada, Mexico)

Evening lecture (September 19, 2019 at 5:30 p.m.)

Into Amazonia: the history of the Amazon River and rainforest

Prof. Dr. Carina Hoorn (University of Amsterdam)

In this presentation I hope to take you with me on a journey that started in 1988 went I first visited the Amazon rainforest. My mission was to document the Tertiary at whichever outcrops I could find and perform palynological analysis of samples to get an insight into the history of the rainforest. My research started at Araracuara (Caquetá Province, Colombia), which means 'home of the macaws', however, this site also had a dark history, as it was a former penal colony for the most dangerous criminals from Colombia. Araracuara is situated along the Caquetá River, which cuts across Paleozoic and Neogene formations. The latter turned out to be a key to the puzzle of how the history of the Amazon and its rainforest unfolded. I will also introduce you to some of the research sites in Peru and Brazil, and even extend to the deep waters at the mouth of the Amazon, which forms part of my more recent research. The data collected and the collaboration with many great colleagues made it possible to lift a tip of the veil and discover some of the history of the Amazon. This story is still unfolding and future work can generate more knowledge on this endangered ecosystem.



Conference dinner on the *Rickmer Rickmers* (September 20, 2019 at 7 p.m.)

The conference dinner of the 25th Latin-American Colloquium of Geoscience is sponsored by Wintershall Dea Deutschland AG and will be held on the *Rickmer Rickmers*, a three-masted cargo sailing ship built in 1896 and at anchor in the Port of Hamburg since 1983 (https://www.rickmer-rickmers.de/). The 97 m long and 12.2 m wide vessel now serves as a museum ship and conveys the highly eventful history of the *Rickmer Rickmers* as a freight sailing ship and marine training vessel. For the delegates of the conference it might be of interest to know that the vessel transported nitre from Chile in the early 20th century.

The conference dinner will start with a reception at 7 p.m. on the upper deck of the vessel. The buffet will be served in the vessels' hulk, which has been restored neatly to a restaurant including a bar. During their stay on board the *Rickmer Rickmers*, delegates will have full access to the exhibitions on the museum decks.

Because of steep staircases, access to the *Rickmer Rickmers* is not recommended for disabled persons with strongly reduced mobility. There is no wheelchair access. Please wear name tag for access to the *Rickmer Rickmers*.

Field trips and guided museum tours (September 21, 2019)

Field trip 1: Palaeoseismic and karst structures in Quaternary sediments of Hamburg and Schleswig-Holstein

Field trip leaders:
Dr. Alf Grube (State Geological Survey of Hamburg, Germany)
Dr. Nils Buurman (Wintershall DEA Deutsche Erdoel AG)

Delegates will meet on September 21 at 9:00 a.m. in front of the Geomatikum and will travel by bus. Delegates will receive a lunch pack. Hiking boots and, depending on weather, waterproof and warm clothing is recommended.

The field trip will showcase unprecedented structural evidence for moderate- to large-magnitude, prehistoric seismic events in the metropolitan Hamburg and nearby Schleswig-Holstein regions (Grube 2018, 2019). The events may be related to the activation of inherited regional faults, including graben and horst structures, notably of the central Glückstadt Graben. The events may have been triggered by glacial loading and unloading and associated isostatic adjustment of upper crust. Depending on outcrop conditions, delegates will witness faults intersecting the Earth's surface, blowout clastic dykes, infill structures, seismic SSDS, seismoslumps, and other soft-sediment deformation structures in Saalian glaciofluvial and Weichselian periglacial material. Salt structures that have bulged to the earth's surface of North Germany are important for a wide range of aspects of applied geosciences. Sinkholes related to Permian rocks are widespread in Hamburg and surrounding areas (Buurman, 2010). Karstification may cause severe damage to existing infrastructure in a densely populated area as Hamburg. The excursion presents impressive sinkholes and introduces investigation methods used to define areas most prone to ground failure and resulting sinkhole development.

Buurman, N., 2010. Charakterisierung von Zirkularstrukturen im geologischen Untergrund Hamburgs zur Abgrenzung verkarstungsgefährdeter Bereiche. – Ph.D. thesis, Univ. Hamburg: 224 p.

Grube, A., 2018. Palaeoseismic structures in Quaternary sediments, related to an assumed fault zone north of the Permian Peissen-Gnutz salt structure (NW Germany) – Neotectonic activity and earthquakes from the Saalian to the Holocene. Geomorphology 328, 15–27.

Grube, A., 2019. Palaeoseismic structures in Quaternary sediments of Hamburg (NW Germany), earthquake evidence during the younger Weichselian and Holocene. International Journal of Earth Sciences, 1-17.

Field trip 2: Geology of the southern North Sea and Heligoland

Field trip leader:
Franz Binot (formerly at Leibniz Institute for Applied Geophysics, Hannover, Germany)

Delegates will meet on September 21 at 8:45 a.m. at St. Pauli Landungsbrücken, Brücke 3/4 at the catamaran (Halunder Jet of Helgolines) in the Port of Hamburg. To get to the St. Pauli Landungsbrücken from the Geomatikum, take the Subway line U3 at station “Schlump” towards “Hauptbahnhof Süd – Wandsbek-Gartenstadt“ and exit after three stops at the station “St. Pauli”. From there, walk for about 500 m down the Helgoländer Allee to the Landungsbrücken and look for the catamaran (Halunder Jet of Helgolines).

Delegates will receive a lunch pack and will then travel with the catamaran to the south port of Heligoland. The trip with the catamaran starts at 9 a.m., takes a bit less than 4 hours one way. This will leave about 4 hours to explore the geology of Heligoland on foot. Arrival back in Hamburg is scheduled for 8:15 p.m.. Hiking boots and, depending on weather, water- and windproof as well as warm clothing is recommended.

Mesozoic rocks of the North Sea Basin rise above sea level in one place only in the German North Sea, which is on the islands of Heligoland. Due to uplift caused by a Miocene salt pillow, the deeper levels of the Southern North Sea Basin strata are excellently exposed on Heligoland. Accordingly, the geological program of the visit will focus on the cliffs in Triassic rocks displaying structural, halokinetic, sedimentological, erosional and metallogenetic features. Moreover, field trip participants will witness the outcome of the construction and dramatic destruction of the island due to human activities, in particular during World War II, which remodelled the natural shape of Heligoland.

Field trip 3: UNESCO World Heritage Wadden Sea

Field trip leaders:
Prof. Dr. Gerhard Schmiedl (Universität Hamburg)
Dr. Ulrich Kotthoff (Universität Hamburg)

Delegates will meet on September 21 at 6:00 a.m. (!) in front of the Geomatikum and will travel in a van to the lighthouse of Westerhever (1.5 to 2 hours). Delegates will receive a lunch pack.

In 2009, the unique Wadden Sea was inscribed on the list of the UNESCO World Heritage. This one-day field trip will lead to the Wadden Sea National Park to explore the sedimentology and actuo-paleontology of the intertidal zone of the southeastern part of the North Sea. At low tide we will study the sedimentological processes and features of a typical tidal flat, including ripple marks, channels, mud areas and sand bars. We will discuss the impact and interaction of the relevant environmental parameters, such as climate, hydrology and availability of sediment on sediment dynamics and coastal evolution. In addition, we will explore the ecosystems of salt marshes and tidal flats with a particular focus on actuo-paleontological aspects including life strategy, ichnofacies, and taphonomy. On our way from Hamburg to Westerhever we pass the typical North German landscapes of marshes and moraines, which were formed by Quaternary glacial advances and sea-level fluctuations, and which were subsequently reshaped by anthropogenic activities like land reclamation.

Our first stop will lead us on a round-trip through the polder, salt marshes, and tidal flats of the “Westerhever Sand” in the vicinity of the picturesque lighthouse of Westerhever (built in 1906). On our way back to Hamburg, we will visit the National Park Center Multimar Wattforum in Tönning where we can learn more about the Wadden Sea and various North Sea ecosystems.

Recommended equipment: The field trip will include a several kilometer walk on the tidal flat, including muddy and shallow water areas. Rainwear and protection against wind and sun are recommended. In addition, fixable sport shoes or rubber boots are recommended for protection against cuts from bivalve shells.

Guided tour 1: Humboldt exhibition at the Zoological Institute

Delegates, who registered to this tour, will meet the tour guide, Dr. Marc Theodor, in the Geological and Paleontological Museum (Geomatikum, Bundesstraße 55). After a brief introduction to this museum, Dr. Marc Theodor will walk with you to the Zoological Museum.

Tour guide: Dr. Marc Theodor

Tour start: 10 a.m.

Duration of the tour: approximately 1.5 hours

Maximum number of participants: 20

Guided tour 2: Loki Schmidt Haus of the Botanic Garden Hamburg

Delegates, who registered for this tour, will meet at the entrance of the Botanic Garden of the Universität Hamburg. To get to the Botanic Garden from the Geomatikum, walk to the U-Bahn station “Schlump”, take the U2 to the station “Jungfernstieg” (3 stops), there transfer to the S-Bahn line and take the S1 to the station Klein Flottbek (8 stops). Meet the tour guide, Janine Peikert, at the entrance of the Botanic Garden.

Join the German natural scientist Alexander von Humboldt (1769 - 1859) on his expedition into nature. Take the perspective of the explorer and his understanding of nature, in which everything is connected. The exhibition „Botany in motion“ shows how Humboldt´s way of collecting and registering plants has changed the understanding of our environment.

Tour guide: Janine Peikert

Tour start: 2 p.m.

Duration of the tour: approximately 1.5 hours

Maximum number of participants: 20

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Abstracts

Impacts of climate and humans on vegetation in northeastern Brazil during the late Holocene

C. Alves de Moraes[1], H. Behling[1], M. Accioly Teixeira de Oliveira[1]

[1]Georg-August-Universität Göttingen, Department of Palynology and Climate Dynamics, Goettingen, Germany

The Holocene is a key period for understanding the role of climate change and the human impacts on the environment. These changes are probably the main drivers of forest-related vicariance and patterns of genetic diversity in the tropics. Vegetation changes are good indicators of climate change/and or human impacts. In this context, a sediment core was collected using the Russian Sampler in a swampy area in the Catimbaú National Park, State of Pernambuco, Northeast Brazil. Although the studied region is located in the semiarid conditions of Caatinga, the coring site is in a particular area providing moist conditions in the Holocene. The collected core is 420 cm long and a basal age of around 2.800 cal yrs B.P. The core was studied by pollen, spores, and sedimentary characteristics as well as dated by AMS radiocarbon dating. The results allow distinguishing three different periods. The first period is characterized by the dominance of Cecropia, indicative of strong disturbances, suggesting relatively dry conditions until 2.160 cal yrs B.P. In the following period, the site is represented mainly by arboreal vegetation, indicating a transition to wetter conditions, between 2.160 and 450 cal yrs B.P. The last period is marked by the presence of more open vegetation as consequent of a return to drier conditions, after 450 cal yrs B.P. Along the core is also possible to recognize the presence of Orbignya palm pollen, what also indicates the presence of human"s disturbance in the area during the late Holocene.

P-t-d path of a garnet-bearing metagranite from the Paleoproterozoic basement of the Tandilia terrane, Rio de La Plata craton, Argentina

M. Angeletti[1], J. C. Martínez[1,2], M. C. Frisicale[1,2], H. J. Massonne[3,4]

[1]Universidad Nacional del Sur, Geología, Bahía Blanca, Argentina
[2]Conicet, Ingeosur, Bahía Blanca, Argentina
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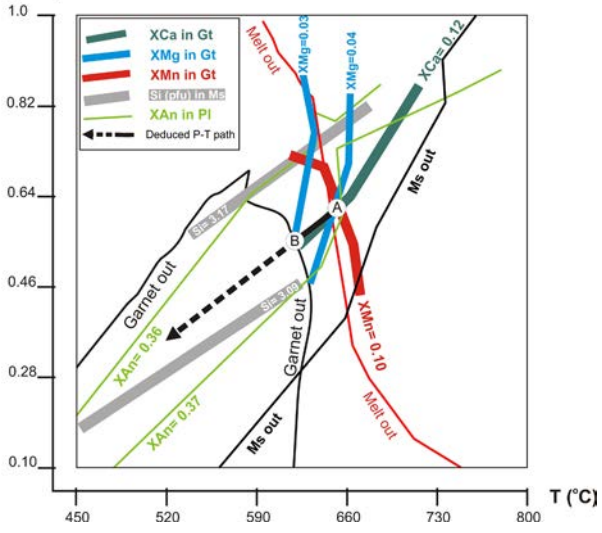
The Tandilia Terrane (TT), in central-eastern Argentina and southeastern Uruguay (Pamoukaghlian et al., 2017) is a Paleoproterozoic igneous-metamorphic complex where the southernmost portions of the Rio de la Plata craton are exposed. The study area includes small outcrops of garnet-bearing metagranite at the La Virgen hill, western TT. To constrain the P-T-d evolution of this rock, we considered microstructures and a P-T pseudosection contoured with chemical parameters of interest. This pseudosection was constructed with the PERPLE_X software for a selected bulk-rock composition in the 11-component system Si-Ti-Al-Fe-Mn-Mg-Ca-Na-K-O-H. The analyzed rock is a slightly deformed, peraluminous (ASI= 1.07), grey granite composed of (~ vol.%): K-feldspar (Kfs, 37), quartz (Qtz, 30), plagioclase (Pl, 18), biotite (Bt, 7), garnet (Grt, 5), muscovite (Ms, 2), and zircon, apatite, monazite, ilmenite (Ilm), and magnetite (Ma) as accessory phases (1). The porphyroclastic texture is characterized by 15 vol.% of a fine-grained (20-100 mm) granoblastic matrix.

The derived P-T path is based on garnet zoning. The garnet core composition pyr4(gro+andr)12spes10alm74, which equilibrated with andesine (XAn = 0.37), yielded P-T conditions of 6 kbar and 650°C (Fig. 1, point A) above the solidus (~7 vol.% of melt). The stable assemblage at these conditions is Ms+Pl+Kfs+Ilm+Ma+Grt+Bt+Qtz+melt, as in the natural rock. Garnet recorded a rimward decreased in pyrope from 4 to 3 mol% by slow cation diffusion to its stability limit which is reached at 5.5 kbar and 620°C (Fig. 1, point B). The subsequent path is constrained by metamorphic muscovite with Si contents of 3.09-3.17 Si per formula unit and XAn= 0.36 in plagioclase.



The deciphered P-T path in the studied rock demonstrates the cooling of granitic material at near solidus conditions and the exhumation from the middle crust (22 km), under an apparent geotherm of ~ 30 ºCkm-1, to upper crustal depths of ~7 km. The ductile microstructures of deformation in the protomylonitic granite are consistent with microstructures in feldspars (deformation twins, myrmekites, and flame perthites) from a 1.5 km distant granitic rock of the Siempre Amigos area

which were restricted between 650º and 430º C (Angeletti et al., 2016). The exhumation path suggested for the studied metagranite is similar to that of the garnet-bearing postcollisional leucogranite of San Veran hill, asigned to Trans-Amazonian orogeny cycle (Martínez et al. 2017).

GNSS-based remote sensing: Innovative observation of key hydrological parameters in the Central Andes

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The Central Andes are characterized by a steep climatic and environmental gradient with large spatial and temporal variations of associated hydrological parameters. In this region, important hydrological components are integrated water vapor (IWV) and soil moisture. Both parameters can be monitored in parallel by using Global Navigation Satellite System - Reflectometry (GNSS-R) techniques.

As part of the International Research Training Group-StRATEGy project, this research aims at monitoring IWV and soil moisture with new station data in the Central Andes. According to the needs of the research, four independent GNSS ground stations were installed for the collection of the data. Each station will be located in different altitude along the climatic gradient and will contain various quality GNSS receivers. It has been shown that some high-quality receivers provide precise measurements, while low-quality receivers have not been widely tested for these applications. A goal of this project is the direct comparison of data quality from each site and receiver type. Additionally, soil moisture sensors will be installed at each site. This set-up will help to evaluate the quality of the GNSS receivers. Moreover, the GNSS-based remote sensing approaches will be directly compared to traditional Time-Domain Reflectometry (TDR) techniques for calibration and evaluation. On-site meteorological stations will be used for studying the relation between the magnitude of precipitation events and soil moisture as well as the time needed to spot a significant change in soil moisture after a precipitation event.

Station	Altitude (m)
University of Salta	1150
Tolombon	1700
Payogasta	2500
Pozuelos	3800

Reference

Wadge, G., Francis, P.W., Ramírez, C.F. 1995. The Socompa collapse and avalanche event. Journal of Volcanology and Geothermal Research 66(1): 309-336.

Mapping marine geothermal resources with the magnetotelluric method in the northern Gulf of California

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Different geological and geophysical disciplines have suggested the Wagner Basin as a promising location of geothermal resources. As a reconnaissance tool Magnetotelluric (MT) data were measured at 10 sites along with a profile over this basin in the northern Gulf of California. The subsurface distribution of electrical resistivity was estimated with two-dimensional smooth inversion using the apparent resistivities and phases from both field polarizations. We also found a deep conductor underneath the center of the basin, interpreted as a zone of partial melt feeding the accretion zone of this young crustal spreading zone. From six MT sites with close-by heat flow measurements, we also found a positive correlation between the interpreted shallow (first 100 m) resistivities and high heat flows. This shows that the MT method can be used to map submarine heat sources. We also found a deep conductor underneath the center of the basin, interpreted as a zone of partial melt feeding the accretion zone of this young crustal spreading zone.

Holocene flank-eruptions at the Lanín Volcano (Southern Volcanic Zone), Patagonia

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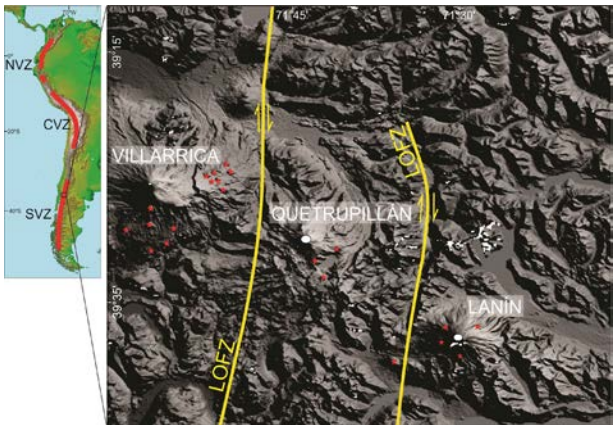
The Lanín (39° 38.34‘S/71° 30.16‘W) is considered an active volcano and is located in the Central South Volcanic Zone (CSVZ) being part of the Villarrica-Quetrupillán-

Lanín volcanic chain (VQLVC). The latter comprises three Pleistocene-Holocene composite volcanoes, aligned in a NW-SE direction, and more than 20 monogenetic volcanoes of similar age.

Five eruptive units with postglacial age (less than ca. 14000 years) are recognized on the Lanín volcano flanks. Through a facies analysis, the conduits and nature of these eruptions are determined. In this way, vulcanian/subPlinian eruptions are interpreted with the development of considerable eruptive columns, followed by strombolian eruptions in the most significant cases. Vulcanian eruptions produced pyroclastic currents and fall deposits with different transport conditions that affected the N and SE flanks of the volcano, at ca. 10000 years.

Through chemical analysis of different eruptive cycle"s rocks, the consanguinity of the involved magma in the eruptive cycle is determined, derived from a singular magmatic system in evolution. The comparison of chemical analyses with those available from the Quetrupillán and Villarrica volcanoes, similar evolutionary histories are interpreted in the magmatic reservoirs of each volcano. That is, basaltic magma recharges in magmatic chambers dominated by fractional crystallization.



Present status and future plans for the Chilean Seismic Network

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The National Seismological Center (CSN) of the University of Chile is currently operating a network of over 80 real-time multiparametric (BB and strong ground motion) stations distributed all over the country, including two Pacific islands. Of these, 10 stations were installed under a program with IRIS within two years after the 2010 Maule earthquake. The main bulk of station installations took place within four years after 2012. This network is complemented by stations of the Integrated Plate Observatory Chile (IPOC) in northern Chile, three Global Seismographic Network (GSN) stations and two Geoscope stations.

128 Global Navigation Satellite Systems (GNSS) stations, 40 of them with on-line real time positioning at the site (RTX), and 297 strong motion instruments -designed for engineering purposes- complement the real time network.

The network was designed to provide fast and accurate estimates of earthquake source parameters -of potentially devastating earthquakes- for emergency response applications, with the capability to comprehensive characterization of Chilean seismicity, necessary for long-term hazard assessment and mitigation activities. In real-time applications, as well as in the near field, the GNSS stations become critical for determination of fault finiteness of M ⍰ 7 or larger earthquakes that affect the coastal part of the country. We will present recent developments in rapid earthquake characterization, including implementation of W-Phase methodology to estimate moment magnitude as well as fault geometry using as examples the observations made for large earthquakes in the country: from the M8.2, April 1, 2014 event to the M6.9, April 24, 2017 earthquake.

Additionally, the network presently covers regions not monitored previously in a continuous manner at this scale, particularly in austral Chile, and clear patterns of seismicity are emerging after four years of operations in these areas.

As for current developments, a prototype of an integrated accelerometer device has been designed and tested for its deployment in Central Chile as part of an Earthquake Early Warning System.

Upper Cretaceous palaeosols as basin analysis proxies: Bauru group (SE Brazil) and Los Llanos formation (NW Argentina)

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The palaeosols constitute powerful palaeoenvironmental and stratigraphic proxies, because during their development they record climate, biology, parent material, time, sedimentation rate and topography. In this respect, palaeosols are useful tools to define the palaeoenvironmental conditions and to unravel the alternation between sedimentation and topographic stability, thus giving fruitful information on type and frequency of the sedimentary processes. The palaeosols are very common in Cretaceous South America continental sedimentary successions.

Using field and laboratorial methods for facies analyses and palaeopedological studies, this paper demonstrates how palaeosols can give useful insights on causes, characteristics and periodicity of the sedimentary processes in two Upper Cretaceous South America sedimentary successions: the Los Llanos Formation and the Bauru Group.

The Los Llanos Formation is a sandstone unit, deposited in a complex system of bajadas. The succession is constituted for 69% of the thickness of cumulative Inceptisols, which suggest low development of the pedogenesis due to autogenic high and regularly continuous sedimentary input.

The Bauru Group is a sandstone unit formed by several distributive fluvial systems. In SE portion of the Bauru Group 89% of the thickness is formed of compound Inceptisols alternated to subaqueous sandstone deposits generated by sheet floods in a distal portion of a distributive fluvial system. Sheet flood deposits buried previous soils and on their deposits developed new pedogenesis. The development of these palaeosols was controlled by autogenic periodic and paroxysmal sheet floods, whose recurring event was of the order of 103 years. In NE portion of the Bauru Group the palaeosol (~60% in thickness) are constituted of Aridisols and Alfisols, alternated to sheet sand aeolian deposits. These alternations signify long periods (of order of 105 years) of topographic stabilisation and pedogenesis in semi-arid or humid climate alternated to arid conditions, which brought aeolian sedimentation. In this case, allogenic factors controlled the palaeosol/deposit alternations. In the E portion of the Bauru Group, compound palaeosols are Entisols, Inceptisols and Vertisols. Inceptisols are located above channel deposits in higher topographic position where the sedimentation rate was reduced. Entisols and Vertisols are positioned in interchannel depressed areas where the sedimentation rate was higher. Sudden depositional episodes covered the soils generating compound profiles. Autogenic factors associated to the depositional morphology controlled the type and distribution of the palaeosols.

Comparative study of deposits and palaeosols allows unravelling frequency, type and magnitude of the sedimentary processes, which can be integrated into the theoretical and applicative analysis of a sedimentary basin.

Water table and biotic effects on Precambrian aeolian depositional systems in Brazil and India

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Three aeolian depositional systems are known: dry, wet and stabilised by vegetation. These types are considered end-members because mixing and overlapping are common in present environments. In the geological record, mixed dry/wet systems are not commonly recognised and aeolian systems stabilised by biotic control are restricted to the Phanerozoic.

Two atypical water table-controlled Proterozoic aeolian systems are here described: a mixed dry/wet system (Galho do Miguel Formation - GdMF) and a system stabilised by biotic effects (Venkatpur Sandstone Formation - VSF).

The GdMF (SE Brazil) is a Mesoproterozoic unit 2,500 m thick, constituted by very fine- to medium-grained metasandstone. Two vertically and laterally interbedded architectural elements can be described: (i)"cross-stratified and planar parallel-laminated beds" and (ii) „flat beds". The first element is constituted of superimposed sets of planar- and trough cross-stratifications, 1-8 m thick, which represent compound or complex dunes (draas) formed of climbing of minor dunes in dry regime. They are alternated to beds with horizontal or low-angle planar-parallel laminations, associated to dry interdune areas. „Flat beds" are composed of horizontal and continuous layers, 0.01-0.7 m thick, showing climbing translatent strata, adhesion ripple and vortex ripple structures, and isolated simple sets of cross-stratifications. „Flat beds" represent low-lying areas with near-surface water table, periodically flooded, displaying isolated and small dunes. „Cross-stratified and planar parallel-laminated beds" probably constituted „isles" above the water table where the construction was associated to climbing of the bedforms. „Flat beds" formed in low-lying areas, close to or at the water table, where the construction was controlled by water. In both systems, the rising of the water table controlled the accumulation. The GdMF is an example where dry and wet aeolian environments coexisted.

The VSF (SE India) is a Neoproterozoic unit 300 m thick, composed of very fine- to coarse-grained sandstone. This is constituted of three elements, alternate in vertical succession: (i) „cross-stratified sandstone", (ii) „planar-laminated sandstone" and (iii) „flat bedding sandstone". „Cross-stratified sandstone" formed in a dune field of small and isolated transverse dunes. „Planar-laminated sandstone" deposited on a dry sand sheet. „Flat bedding sandstone" is constituted of biolaminites, associated to other microbially induced sedimentary structures, and alternated with adhesion and vortex ripples. This element formed on a damp, occasionally wet, sand sheet. Water table controlled the accumulation of all the three elements, but microbial mats contributed to the construction and accumulation of „flat bedding sandstone". Thus, VSF is an example of Proterozoic aeolian system formed with the contribution of biotic effect.

Kinematics of subduction processes during the earthquake cycle in Central Chile

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Subduction processes at convergent margins produce complex temporal and spatial crustal displacements during different periods of the earthquake cycle. Satellite geodesy observations provide important clues to constrain kinematic models at subduction zones. Here we analyze

geodetic observations in Central Chile, where two large earthquakes occurred: Maule in 2010, Mw=8.8, and Illapel in 2015, Mw=8.3. We propose a model that considers the motion along both interfaces of the brittle subducting slab as the sources responsible for the movement of the crust in the different periods of the earthquake cycle. Using standard inversion techniques, we provide a consistent framework of the kinematic displacement during each period of the earthquake cycle. We show that during the interseismic period prior to Maule and Illapel earthquakes, two patches of slip-rate on the lower interface are determined. These patches are located just below the future hypocenters. Since the interseismic period corresponds to the loading process and the coseismic to the unloading process, it is interesting to note that the area where loading is stronger corresponds to the area where unloading is also strong. Furthermore, we show that the Maule earthquake causes a significant displacement on the lower interface, just below the epicenter of the future Illapel earthquake to the north, a few years later. We speculate that the interaction between motion along both interfaces are the key to understand the evolution of stress and the occurrence of earthquakes at subduction zones. This framework improves the understanding of the observed loading and unloading processes, and potential triggering between subduction earthquakes.

Subduction kinematics in the years before and after the 2014, Iquique Mw 8.1 Earthquake, Chile from de-noised GPS trajectories and joint slip-strain models.

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Over 5 years have passed since the April 1st 2014 Mw 8.1 Iquique earthquake in Northern Chile, during which time we have captured the relaxation processes of this large event with both seismic and geodetic instruments of the Integrated Plate boundary Observatory Chile (IPOC). While there exist some Iquique afterslip models that use GPS and InSAR recorded ground motions, we have not yet explored the spatiotemporal interplay between afterslip, aftershocks, and mantle relaxation. Furthermore, several studies that have explored the seismic and geodetic variations leading up to the event have come to different conclusions: At this point it remains unclear as to whether the gradual failure of the asperity starts accelerating just a few weeks or several months before the mainshock.

Here we will show the results of applying the Greedy Automatic Signal Decomposition (GrAtSiD) algorithm to the IPOC continuous GPS stations, along with the associated kinematic models of the uncoupling and relaxation processes. With GrAtSiD, we are able to automatically separate the seismic and aseismic signals in the GPS time series, as well as being able to remove most of the seasonal oscillation. We will first describe the features of the decomposed GPS velocities and then present models of the plate-interface kinematics and mantle relaxation, for periods both before and after the earthquake. For the kinematic modeling we will show our progress with state-of-the art models that simultaneously solve for strains in cuboid volumes and slips on faults. While this modeling approach suffers computationally from the need to solve a tremendously large model space, the advantage is that it eliminates the model bias introduced by the traditional approach of relaxing coseismic stresses in a pre-defined arrangement of elastic and viscoelastic model blocks.

The Miocene foreland basins of Northern Patagonia: sediment transfer systems from the Southern Andean to the Atlantic shelf

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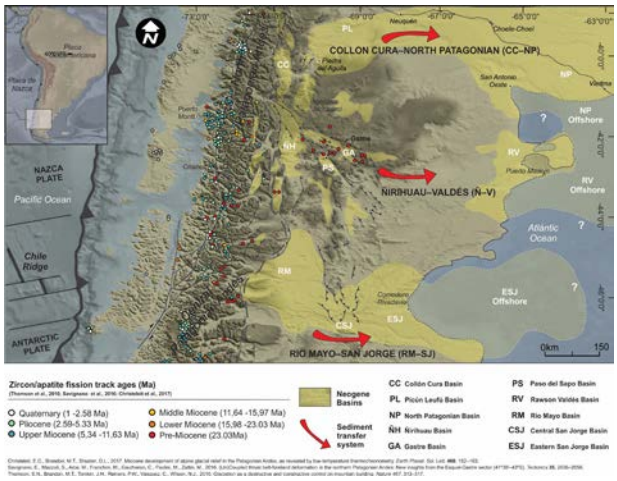
Unravelling the effects of external controls on the stratigraphic record of a region, as well as the determination of how they impact in the dynamics of a sedimentary system is nowadays a critical gap to solve in geosciences. This issue is challenging because it not only involves the net depositional parts of the systems, but also, implies the understanding of the dynamic interplay between erosion, sediment transfer, and deposition as well as temporary storage, and long term preservation of the sediments, from source to sink.

The Northern Patagonia has an extensive and superbly exposed Neogene Andean foreland sediment record extending from the foot of the Southern Andes to the Atlantic shelf. This sediment transfer system is strongly linked to the Neogene orogenic growth of the Andes and was synchronously associated with the development of profuse magmatism, a major climate change from wet to dryer conditions, as well as important relative sea level changes. Based on a multidisciplinary approach, which includes new structural, stratigraphic, geomorphological and geochronological dataset together with previous surface and subsurface regional surveys, three Miocene sediment transfer systems that connected the Andes with the Atlantic Ocean through more than 600 km were reconstructed. From north to south (45–48°S) these transfer systems are: Collón Cura–North Patagonian basins system, Ñirihuau–Valdés basins system and

Rio Mayo–San Jorge basins system (Fig.1).

Stratigraphic correlations along the sediment transfer systems indicate a continuous sedimentary record during the Miocene for the Collón Cura–North Patagonian and the Río Mayo–San Jorge basins system. However, for the Ñirihuau–Valdés system, an important hiatus is registered in the distal zone during the middle Miocene (i.e., Rawson-Valdés Basin). This stratigraphic gap is interpreted as a consequence of middle-term sediment transient storage in the foreland region during the middle Miocene associated with block uplift and the configuration of closed-basins. Thus, during the Miocene sediment transfer systems functioned as both fully connected and unconnected systems between the Andes and the Atlantic Ocean. Finally, although more studies are needed to refine and improve the chronostratigraphic framework of the Miocene sediment transfer systems, early results of this work show some relevant issues related to the origin of environmental signals and their propagation through time and space.



The Central Andean double seismic zone: seismological constraints on the processes within

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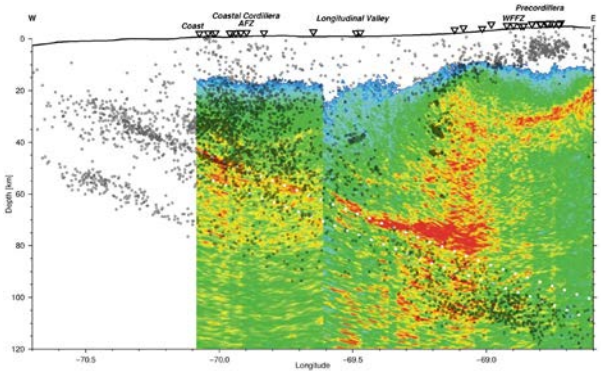
Subduction zones worldwide show a common pattern where earthquakes occur in two slab-parallel planar structures, so-called double seismic zones. One plane is located below the plate interface, within the oceanic crust or mantle, the other one, separated by a few to tens of kilometers, inside the slab mantle. The processes that cause earthquakes to occur in this particular geometry at intermediate depth are highly debated.

Temporary local seismic networks and the permanent regional IPOC network facilitated the detailed observation of the Central Andean double seismic zone. The ANCORP 96 active source seismic deep sounding experiment allowed correlation of detailed structural images with seismicity patterns. Here, we summarize our recent efforts to characterize the petrophysical properties and the stress state of the subducting slab from seismological observations.

The plate interface of the Central Andean subduction zone becomes activated in weak thrust faulting events down to a depth of 50-km and appears as a sharp reflector. At 50-km depth the coupling zone ends, the reflectivity pattern of the plate interface broadens characteristically and the slab is under tension. The upper seismicity plane consists of seismic events that likely activate outer-rise bend-faults. It has a homogeneous lateral extent. The P- to S-wave velocity ratio is indicative of metamorphosed oceanic crust.

The lower plane of seismicity is laterally heterogeneous on a scale of tens of kilometers. Differential stresses are low in the updip portion of the slab and increase along the subduction pathway with no apparent signature of reactivation of inherited structures. At the commence of the lower plane of seismicity we find a high P- to S-wave velocity ratio that is indicative of the presence of a connected network of fluid-filled vein-like pores. Along the ANCORP profile the places where the lower plane of seismicity is present correlate with an increased seismic reflectivity above, which we interpret as the signature of fluids escaping into the overlying slab mantle.

At 100-km depth, seismicity and seismic reflectivity increase strongly within the slab. Above, a prominent reflectivity structure is visible which connects the top of the slab with the magmatic arc and fosters the interpretation that this is the place where major slab de-volatilization occurs.



Tectonic and climatic coupled processes in North Patagonian Andes: Miocene orographic barrier uplift and rain shadow generation

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The relationships between climate and tectonic processes are in the geoscience spotlight during last years. The uplifting of a mountain range may constitute a topographic barrier to atmospheric circulation, thus producing the generation of an orographic rain shadow capable of driving important climatic and ecological changes. The link between tectonic and climatic processes has been analysed in several regions of the world. As for the Andean chain, a main phase of orogenic growth occurred during the Miocene, configuring several Andean segments. Some of them were widely analysed, and tectonically controlled climate changes were established. Several works indicate that, in late Miocene times, the orographic uplift of the Central Andes triggered meaningful climatic changes, from wet to dryer conditions. The Southern Andes remain less understood in terms of tectono-climate interactions, and only a few semi-quantitative approaches were addressed for the past 20 Ma. In this work, we analyzed a continuous palaeosols succession recorded in a North Patagonian Miocene foreland basin in order to understand the moisture regime changes in response to the uplifting of the Patagonian Andes. Based on macromorphological, micromorphological and geochemical analysis, supported with a time scheme, the palaeosols were characterized with their corresponding Mean Annual Paleoprecipitation (MAP) and Mean Annual Temperature (MAT) values. Alfisol-like palaeosols were identified at the base of the foreland infill (15-14.6 Ma) with MAP of 1229 ± 108 mm/yr. Andisol-like palaeosols were recognized in the middle section of the sequence (14.6-12.75 Ma) with MAP of 1056 ± 108 mm/yr, whereas Aridisol-like palaeosols localized at the top of the infill (12.75-11.5 Ma) presented MAP of 677 ± 108 mm/yr. Mean Annual Temperatures has not meaningfully changed since the Miocene (~11 ± 2.1°C) to the present (11°C). These data indicate a continuous decrease in MAP (>600 mm/yr) and stable MAT between 15-11.5 Ma for the North Patagonian extra Andean region. The decrease in the rainfalls may be related to the uplift of the Patagonian Andes and the rain shadow generation. The results indicate that although the Patagonian Andes started the uplift around 19 Ma, a time-delay of ~4 Myr with the rain shadow generation occurred, and the rain shadow effects were effectively recorded since ⍰14.6 Ma. Therefore, between 19-14.6 Ma, the North Patagonian Andes were not high enough to generate a rain shadow effect.

New insights about South American hydroclimate changes during Heinrich Stadials

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Heinrich Stadials (HS) are cold Northern Hemisphere abrupt millennial-scale events frequently related to decreases in the strength of the Atlantic meridional overturning circulation (AMOC). Model simulations and paleoclimate records indicate that the reduction in oceanic heat transport to the Northern Hemisphere during periods of weak AMOC cools down the North Atlantic and warms up the South Atlantic. This perturbation in the cross-equatorial heat transport would in turn affect tropical rainfall. Indeed, South American hydroclimate records indicate marked precipitation anomalies during HS of the last glacial period. However, the scarcity of high-resolution marine records off South America, especially between 7 and 20°S, hampers a mechanistic understanding of tropical South American hydroclimate responses to HS. Here we investigate piston core M125-95-3 collected at 10.95°S from a site influenced by the terrigenous discharge of the São Francisco River, eastern South America, for the last ca. 70,000 years. In order to reconstruct changes in precipitation over the São Francisco River drainage basin we determined the major elemental composition along the piston core. To gain mechanistic insights into tropical South American hydroclimate changes we analyzed a HS-simulation with a high-resolution version of the atmosphere-ocean general circulation model CCSM3. Our new elemental record shows marked increases in São Francisco River sediment discharge to the eastern South Atlantic during HS. It is the southernmost marine paleoclimate record off eastern South America that unequivocally records the HS of the last glacial period. Additionally, our high-resolution model output allows new insights into the drivers of changes in South American hydroclimate during HS.

Multi-physics inversion of gravity and magnetic data in Los Humeros Super Hot Geothermal System, México

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Over the last decades, the worldwide increasing demand for clean energies has become the geothermal energy an important alternative resource. The GEMex project is a

cooperation on geothermal energy research of a Mexican and European consortium focused on the study and development of two geothermal zones in Mexico. The first place is a candidate for Enhanced Geothermal System (EGS) at Acoculco, within a Pliocene-Pleistocene volcanic complex with high temperatures found from two exploration wells but low permeability. The second place is a Super Hot Geothermal System (SHGS) at Humeros, within a Quaternary volcanic complex with super hot temperatures about 380° C near a conventional system that is currently being exploited. Since geothermal resources are located beneath the surface of the ground, non-invasive and large coverage geophysical data play a key role for the definition of deep structures. In this study, we present a 3D regional joint inversion of gravity and magnetic data from the Los Humeros Volcano Complex (LHVC) that includes the conventional and super hot geothermal fields. We developed a versatile algorithm to jointly estimate density and magnetization 3D structures using gravity and magnetic data that takes advantage of direct unknown relationships that allow preserving the resolution of individual methods and rely more on the properties values themselves in contrast to structural minimization approaches that rely more on the properties changes. The results from joint inversion showed a link between low density, low magnetization and major fault zones with high relevance to geothermal assessment. In general, a more accurate integrated subsurface image is achieved in our joint inversion approach. Finally, the 3D magnetization and density models are expected to be used as important constraints in the electrical and seismic modeling which as a whole will help us to the construction and understanding of the geothermal conceptual model.

Metal accumulation in surface sediment of the urban and industrial coastal area of the municipality of Moa (Cuba): distribution and pollution assessment.

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The investigation is to evaluate the accumulation of ten elements (Al, Cr, Fe, Mn, Ni, Co, As, Cu, Pb and Zn) in surface sediments from the urban and industrial coastal area of Moa. Human activity has influenced the region, which has been developing in one of the most important mining regions of Cuba since the middle of the past century. Two methods were used to assess the contamination of the sediments: the estimation of metal enrichment by calculating the index of geo-accumulation (Igeo) and the interpretation of the data obtained based on quality criteria. The overall range of concentrations is 15.7 - 83.5 mg g-1 for aluminum, 1.4-17.9 mg g-1 for chromium, 22.8 - 379.5 mg g-1 for iron, 1.5 - 56.2 mg g-1 for manganese, 0.9 - 6.2 mg g-1 for nickel, 56 – 1094 µg g-1 for cobalt, 6 -126 µg g-1 for arsenic, 17 to 146 µg g-1 for copper, 6 - 66 µg g-1 for lead, and 64 - 576 µg g-1 for zinc. The results obtained from the studied coastal zone show a high level of pollution in surface sediments. The spatial distribution of the elements varied according to the analyzed elements: Al, Cr, Fe and Ni showed high levels of concentration throughout the studied zone; Mn, Co, Cu, As and Zn are in a higher proportion in Moa Bay Cay. In the case of As and Pb, higher concentrations were located at the deltas of Moa and Cayo Guam rivers and also in some areas in the west of the bay.

Thermochronology of the São Francisco Craton and Araçuaí-Ribeira Orogenic System Transition

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The São Francisco Craton (SFC) southern portion, most known for hosting the mineral province of the Quadrilátero Ferrífero (Iron Quadrangle) is surrounded by Brasilino orogenic belts in all sides but the Atlantic coast. The Araçuaí-Ribeira orogenic system (AROS), located on the southeastern margins of the São Francisco Craton is assembled by the Araçuaí orogen to its northern portion and the Ribeira belt to the south. This report presents monazite and rutile U-Pb ages and the application of the Zr-in-Rutile-Thermometer for the understanding thermochronology of the SFC and AROS Transition.

Two distinct sample sets were evaluated. One represents monazite collected on the quartz veins associated with the deformation of the metapelitic rocks from Serra de Santa Helena Fm. and other represents rutile from metaultramafic rocks of the Quebra-Osso Group. Both monazite and rutile compositions were determined with JEOL electron microprobe (EMP) JXA-8900 through Wavelength-dispersive X-ray spectroscopy (WDS) and the monazite imaging through backscattered Electrons (BSE). The Monazite age obtained through U-Th-PbT dating method resulted in 538+-23 Ma for monazite crystallization. The U-Pb data of the rutile crystals were achieved by Sector Field LA-ICP-MS equipped with a CETAC LSX-213 Nm G2 laser ablation system equipment. Tera-Wasser burg ages were calculated using Isoplot. The age obtained was 540.3+-4.4 Ma for rutile recrystallization.

For the metamorphism analyses in the studied area, the Zr-in-Rutile-Thermometer was adopted. In alpha-

quartz stability field the temperature may be obtained as follows:

T (oC) = [(83.9 + 0.410Pkbar)/(0.1428 - RlnppmZr)] – 273, where R = 0.0083144 kJ K-1

The adoption of the known regional 7kbar pressure resulted in an average temperature of 571°C with 8°C of standard deviation.

The known regional metamorphic peak around ~570 Ma, with temperatures over 600 °C would have reset the rutile U-Pb system during its recrystallization in the metaultramafic rock until the closure of the U-Pb system at 540 Ma. Thermochronology of the SFC and AROS transition at ~540 Ma and ~570 °C suggests the idea of a post-orogenic collapse and retrograde metamorphism at the end of Precambrian.

Tipping elements of the climate system and marine sediments: The Western tropical Atlantic and the adjacent South America

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The Atlantic meridional overturning circulation (AMOC) as well as the Amazon rainforest (ARF) have been considered policy-relevant tipping elements of the climate system. In short, this means that: (i) they may pass a critical threshold at which a small perturbation may significantly change the way they function; and (ii) anthropogenic forcing may prompt the critical threshold to be exceeded. The possible consequences of exceeding this critical threshold include a collapse of the AMOC and a dieback of the ARF. These two tipping elements are particularly relevant for the tropical Atlantic Ocean and adjacent South America. Despite their relevance, large uncertainties are associated with these tipping elements and there is an urgent need to improve our understanding of the physical mechanisms controlling them. Here we show a selection of classic, recent and unpublished studies based on geological archives that recorded the response of the tropical Atlantic Ocean and the adjacent South America to a marked slowdown in the AMOC that occurred between ca. 18.1 and 14.7 cal ka BP (Heinrich Stadial 1). During the AMOC slowdown, the mid-depth (~1000-3000 m water depth) western tropical Atlantic Ocean experienced a major stagnation (probably the largest in the Atlantic Ocean) that allowed for a marked accumulation of respired carbon. In the upper water column (uppermost ~200 m), the shallowest portion of the mixed layer migrated southwards following a shift of the Intertropical Convergence Zone and impacting the distribution of nutrients in the equatorial Atlantic Ocean. The southward migration of the Intertropical Convergence Zone together with positive sea surface temperature anomalies both in the western tropical Atlantic Ocean and the eastern equatorial Pacific Ocean produced positive precipitation anomalies all the way from NE Brazil to western Amazonia. The positive precipitation anomaly over Amazonia was, however, divided in two phases that distinctly affected Amazonian hydroclimate and the ARF. The transition from the first to the second phase was characterized by: (i) a migration of the main locus of precipitation from the tropical Andes to central Amazonia; (ii) a southward shift of the tropical rain belt with a marked decrease of precipitation over northernmost Amazonia; and (iii) a strong reduction in western equatorial Atlantic sea surface salinity despite the sluggish AMOC. Finally, the southward migration of the tropical rain belt produced a decrease in the area covered by the ARF, most probably in its northernmost reaches where open vegetation types expanded. Thus, geological archives from the tropical Atlantic Ocean and adjacent South America allow exploring the multiple flavors of two tipping elements, namely AMOC and ARF. These flavors cannot be otherwise explored in the short instrumental record but contribute to an improved understanding of the physical mechanisms controlling them.

Structure and geodynamics of the collision zones of the Nazca and Juan Fernández Ridges with South America

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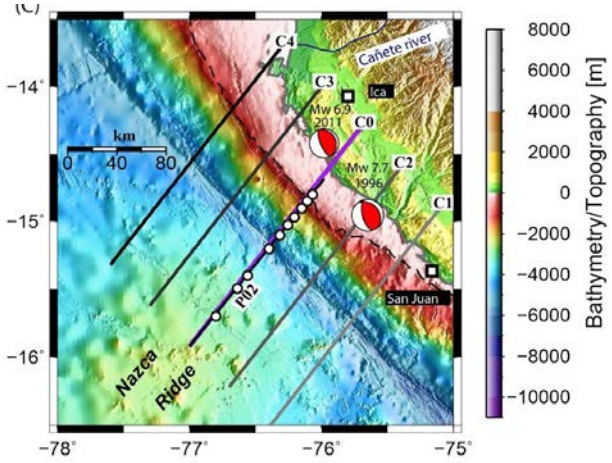
The west coast of South America is a major plate boundary where the oceanic Nazca Plate „is forced to subduct“ beneath the continental South American Plate. This plate boundary generates magnitude 8-9 earthquakes on a regular basis, such as the historic Peruvian 1868 and Chilean 1960 megathrust earthquakes. The seismogenic segments and the structure of the continental margin along this subduction zone are influenced by topographic ridges on the oceanic plate that are caused by hotspot tracks, representing lines of volcanoes generated by partial melting due to hot plumes rising within the Earth‘s mantle. Examples include the Juan Fernandez Ridge (JFR), which was formed far from the East Pacific Rise on a off-ridge setting. and the Nazca Ridge (NR), which was formed near the East Pacific Rise. The crustal structure of these hotspot tracks differs in thickness and composition.



The JFR presents a normal oceanic crust ~7 km thick with large extrusive seamounts of up to 4500 m surrounded by a rough topography. In contrast, the NR hosts an overthickened oceanic crust of 17 km thick with large amount of crustal intrusion material. The surrounded seafloor of the NR is smooth and shallow (swell topography 150-200 km wide and up to 1.5 km high). This swell topography was formed by the thermal effect of reheating the oceanic lithosphere during its interaction with a hotspot plume and the buoyancy effect of the anomalously overthickened crust. Flexural models show that the JFR was fomed onto relatively old and rigid oceanic lithosphere ~37 Ma with an elastic thickness (Te) of 10-15 km. In contrast, the swell topography of the NR is consistent with a flexural model with little elastic rigidity (isostatic compensation or Te < 2 km) consistent with a hotspot ridge formed near an active spreading center.

Landward, the ridge-trench collision zones of the JFR and NR are characterized by subsidence and subduction erosion of the continental wedge and the presence of a slope trenchward-dipping scarp (1000-1500 m of vertical offset) at the slope-shelf transition. The continental shelf is uplifted and underlying by high seismic activity correlated to the subduction of the Nazca and Juan Fernández Ridges. Linking the earthquake rupture characteristics of large underthrusting earthquakes and the deep structure of the NR and JFR suggest that these oceanic ridges act as both asperities and barriers for earthquake rupture propogation. This dual behavior is complex and can be controlled by a combination of factors including the subduction erosion degree, buoyancy forces of the subducting ridge, elastic energy acumulated during the interseismic period, and the hydrological properties of the frictional contact among others factors.

Towards visualization possible fluid pathways using gravity in the Los Humeros and Acoculco Geothermal Fields

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GEMex is a cooperation project in geothermal energy research is being carried out between Mexico and the European Union since the end of 2016 for development of Enhanced Geothermal Systems (EGS) and Superhot Geothermal Systems (SHGS) in two unconventional sites in Mexico, Los Humeros and Acoculco. Both geothermal fields are located in volcanic settings within the Trans-Mexican Volcanic Belt. Los Humeros field in currently under exploitation and the area to the north of the current production if significantly hotter, with more than 380°C. The high temperatures and the water chemistry are the principal challenges in this part of the reservoir. On the other hand, in Acoculco, only two exploration wells have been drilled. The temperatures rise to about 300°C at a depth of 2 km. The high temperature gradient and the undiscovered resource makes it an interesting target for exploitation and testing of our knowledge.

This study aims at visualize and characterize reservoir condition in Los Humeros using gravity by calibrating the data with data from the geothermal wells. In a second step the transferability of the findings to the northern part of Los Humeros and in a third step to Acoculco site will be tested. To accomplish this, In Acoculco, a total of 84 gravity stations were acquired in an about 5 x 3 km rectangular grid oriented NE-SW and NW-SE with a typical station distance of 400 m to each other. In Los Humeros, a total of 344 gravity stations were measured in two different surveys. In the first campaign 263 stations were measured along ten E-W profiles of 5.5 km length with typical inter-station and inter-profile distances of 200 m and 500 m, respectively. The survey was completed by a NE-SW oriented and 31 km long profile across the study area. This profile includes 81 gravity station with an inter-station distance of about 375 m. In total, 341 stations were used for further evaluation in Los Humeros field.

From Bouguer anomalies, residuals anomalies were calculated and analyzed in a pseudo-tomography by Butterworth filtering. Caldera structures as well as faults were identified. In order to obtain unconstrained information on the influence of the caldera and fault structures, inverse modeling was carried out.

Both, residual anomalies and inversion results reveal a high fault control on the gravity and thus the density distribution. The alignment of the majority of the anomalies follows NE-SW and NW-SE trending fault orientations. At reservoir level, in Acoculco, a significant high-density anomaly is observed down to sea level in the area, where the two geothermal wells were drilled. At Los Humeros,

the N-S trending secondary faults in the northern part of the geothermal field also coincide with relatively high-density anomalies, whereas the NE-SW to E-W trending secondary faults are characterized by low-density.

Regional transect across the Quirquincho Arch (NW Argentina)

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The Chaco-Pampean plain of the Argentine Andean foreland covers the Chaco-Paranaense intracratonic basin and the eastern portion of the Cretaceous Salta Rift basin. At surface, there is no direct evidence for a complex tectonic history of this region. Subsurface data, however, document a geological history of magmatic episodes, multiple tectonic events and sedimentation controlled by tectonics. Inherited subsurface structures are characterized by a preferential NE-SW orientation. This orientation is also broadly reflected by the overall trends of the adjacent Sierras Pampeanas broken-foreland province, the Colonia-Aldao High and the Las Breñas depocenter. This study compiles and reviews available subsurface information including borehole data, 2D seismic-reflection lines and topographic data to reconstruct the tectono-sedimentary history along a regional NW-SE transect between Tartagal (Salta province) and Formosa city (Formosa province); key focus is the analysis of the multi-episodic activity of the Quirquincho Arch (also known as the Rincón-Caburé High). This structure is an extensive and prominent basement ridge that constitutes the boundary between the Chaco-Paranaense basin and the Salta Rift depocenters. Tectonic activity along the Quirquincho Arch is interpreted to have controlled the facies distribution of syntectonic sequences in the two adjacent basins during the Paleozoic and Mesozoic.

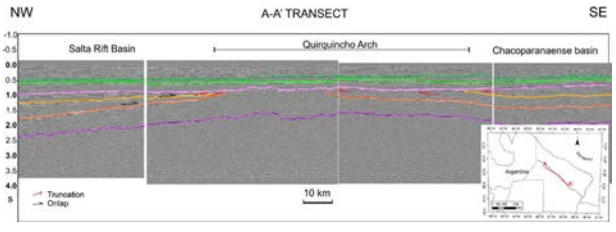

Figure 1. Seismic transect across the Quirquincho Arch.

The interpretation of 2D seismic-reflection data and well-log information allowed to identify the exact subsurface position and shape of the Quirquincho Arch. Its presence is unambiguously reflected on various seismic-reflection lines (Fig. 1). The arch is characterized by multiple reflection terminations at its top and flanks; the interpretation of onlaps and truncations enables the reconstruction of its tectonic history.

Deformation and differential subsidence in the Neuquén Basin, outlines for hydrocarbon exploration

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The Neuquén basin is one of the main hydrocarbon producers in Argentina and also has one of most potentials in the world from the capitalization of its main source rock: the Vaca Muerta Formation. Its history started by the development of a rift system during Late Triassic – Early Jurassic, subsequently filled with sag facies characterized by successive regressions and transgressions of eustatic origin. The Triassic extension was resolved with normal faults of NO-SE to ONO-ESE orientation and transfer zones of NE-SW orientation. Since Cretaceous, it became a foreland basin linked to the Andean orogeny, that printed in the western sector, a N-S fault and thrust belt. However, this apparently simple history has some particular complexities. Towards the south of the basin, a narrow E-W trending fold and thrust belt was developed during Middle Jusrassic – Lower Cretaceous. The inversion of some of the Triassic structures, developed an E-W structural height (Huincul) that controlled the facies distribution during Jurassic and Cretaceous. Both the Jurassic and the Cretaceous-Tertiary (Andean) compressional deformation, invert some of the Triassic structures. However, unlike what was initially assumed, the inversion effect was not as important. This is mainly because, both compression vectors are oblique to the Triassic structures and therefore only some segments of some faults were inverted. The Jurassic compression, from south, printed a dextral component in the southernmost NO-SE Triassic faults, whereas the Cretaceous-Tertiary Andean orogeny, printed a sinistral component over the westernmost NO-SE Triassic faults of the basin. To the southwest of the basin, the extensional structures and both principal compression vectors are overlapped, developing areas with very complex structures. Making things even more complex, the differential subsidence mechanism is over imposed to all deformation process. This is a less spectacular process, however, is very fundamental for hydrocarbon distribution in the basin. The differential compaction between basement and Triassic half grabens infill, controlled a series of normal faults that grew during early Cretaceous grouped above Tri-

assic shoulders. These structures conditioned the migration and accumulation of the hydrocarbon in some of the biggest gas and oil fields of the basin. The effect of differential subsidence is continuous over time, and controls even current basin troughs. Its consequences, are more evident and visible in areas of low compressive deformation, however, there are also recognized in the Jurassic (Huincul) and Cretaceous-Tertiary (Andina) fold and thrust belts. The effect that this mechanism could produce a distortion in the present stress field of the basin that is currently being studied. The understanding of this process is very important for planning developing of non-conventional fields in Vaca Muerta Formation.

Tracing the volcanic and tectonic effects of the Miocene Andean stage along the Patagonian retroarc: an example of the Río Negro system, Argentina

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The Río Negro River system constitutes a drainage network located at the North Patagonian Region (39°S) that connected the Andes with the Atlantic Ocean through more than 600 km long. This corridor is one of the systems that control the transference of materials to submarine shelf, up to sink position, in the Argentina basin. During the Neogene this system was configured in a scenario of profuse arc-explosive volcanism, contractional tilt-block tectonics, the development of the orogenic rain shadow, as well as relative sea level changes. Several fault-bounded exoreic–closed-basins along the retroarc present infill that record endogenous and superficial processes occurred during the birth of the Andean chain, at this latitude, as we observe it today. Even though large-scale stratigraphic scheme and holistic geological models were performed to go forward in the understanding of the system, until now are absent high resolution tectonic-volcano-climatic-eustatic models that allow to understand the sediment supply/accommodation space relationship and the reciprocal stratigraphical effects along the whole system, in which the propagation of the environmental signals be consider. Based on a multidisciplinary approach, which includes structural, stratigraphic, geomorphological and geochronological dataset together with previous surface and subsurface regional surveys, the analysis retroarc basin along Río Negro system is carrying out. The preliminary results indicate that many contractional phases related to out of sequence, thick-skinned tectonics, progressed under explosive volcanism which affected in different way the system, according to the frequency order measured and location along the system. At the foot of the Andes, preliminary geochronological and magnetostratigraphic analysis reveals that the main infill of the basins has a maximum depositional time process of 128 Ky related to PDC as well as resedimented volcaniclastic materials, whereas along the system their show changes in the infill patterns and in the transference systems occurred during middle-upper Miocene. These changes are recorded together with huge climate change related to the uplift and exhumation of the Andes, connection/disconnection of the system with shelf and sea level variations. Future works will aim to the understanding how the subtle interplaying of tectonic-volcano-climatic-eustatic forcing controls determine the reciprocal stratigraphy and its propagational effects from the Andes to the Atlantic sea.

Stratigraphic architecture in early stages of intermontane basin: the Miocene Calchaquí foreland, NW Argentina

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Foreland basins are sensitive recorders of spatiotemporal variations of tectonic and climatic forcing concerning to processes associated with an approaching orogenic front. The analysis of depositional systems, and paleoflows coupled with stratigraphic arrangement of the foreland deposits allows a fairly accurate assessment of extra and intra basin deformational processes. The Calchaquí region, located at ~24-26°S in the Eastern Cordillera of NW Argentina, was once part of the contiguous Andean foreland basin that evolved structurally into a compartmentalized broken foreland during the Mio-Pliocene. This region is ideal for the study of the variations in tectonic, climatic and sedimentary processes, due to very well exposed of basin strata that contain a rich record of flora and vertebrate fossils, and radiometrically datable volcanic ashes. We combined traditional sedimentological methods, U-Pb zircon and K-Ar geochronology, clay mineralogy, and geochemical weathering/climate indices with structural field data and fault modeling to document the stratigraphic response of the former foreland deposits to basin fragmentation. The 14-9 Ma Las Flechas Member (upper Angastaco Formation) and the 9-5 Ma Palo Pintado Formation comprise three depositional systems and transitioned from gravelly braided, sandy braided to anastomosing-river systems. The slow transition from sandy to gravelly braided and the rapid transition from gravelly to anastomosing reveal a prograding-retrograding pattern of the sedimentary sequences highlighting an expansion surface. Thus, the regional sedimentary succession recording the transition between an unrestricted to a compartmentalized

foreland is represented by the sharp contact between gravelly braided and the anastomosing that must have occurred by ca. 9 Ma. The new data suggest that fluvial depositional systems changed several times in terms of location and style and were associated with pro- and retrograding gravel wedges, most likely in response to multiple fault reactivations of the basement and inversion of normal faults most likely in response to structural growth of the eastern basin-bounding ranges of the Eastern Cordillera.

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Approaching the organic carbon balance: Interaction of climate, tectonics, erosion and biota in riverine carbon transport and respiration at the Bermejo River

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Riverine transport is now recognized as a major pathway of terrestrial organic carbon (Battin et al., 2009). This transport can either contribute or consume significant amounts of atmospheric CO2 on geological time scales and therefore impacts on both, the regional and global carbon budget (Hilton et al., 2008). Geomorphic and climatic processes determine if organic matter serves as source or sink of atmospheric CO2 (Clark et al., 2017). Further, tectonic and climate feedback and their interaction with geomorphology and bioproductivity may have major impacts on carbon cycling, though these are not yet well constrained (Hilton, 2017). To quantify the organic carbon budget, it is essential to gather knowledge about the origin, age and relative importance of the riverine organic carbon (Grace and Malhi, 2002). Active mountain belts with high sediment supply may contribute to atmospheric composition through sequestration of biospheric organic carbon on significant level (Hilton et al., 2008).

The Bermejo River originates from the Andes Mountains of north-western Argentina and southern Bolivia and crosses significant elevation and climatic gradients. Its tributaries carry distinct loads of sediment and cross different climatic conditions and therefore are supposed to show different internal dynamics of in-stream coarse organic matter. We aim to understand the role and control of organic carbon bedload transport of the Bermejo River. By using bedload sampling techniques, we investigate the driving factors of this transport and how climate and geomorphology govern it. Further, we want to constrain which processes occur during the mobilization and transport of organic carbon. Therefore, we aim to quantify the riverine-atmospheric carbon feedback and how it is influenced by river mobility and bioproductivity. In order to trace back sources and composition of the riverine organic carbon, we combine sampling of organic carbon bedload transport and riverine CO2 evasion with isotopic measurements. We quantify the organic carbon budget and constrain the fate of organic carbon in riverine transport to improve our knowledge of the underlying processes controlled by climate and tectonics.

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Along-strike crustal strength gradient accounts for the GPS velocity field in the Southern Andes: evidence from scaled analogue experiments

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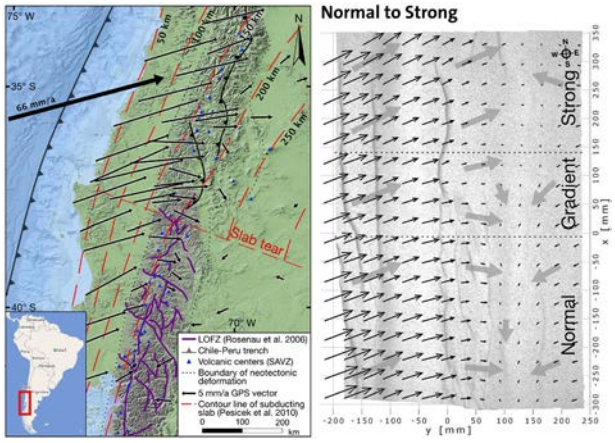
Dextral transpessive deformation in the Southern Andes caused by oblique subduction of the Nazca Plate below the South American Plate is widely believed to be focused on the 1200 km long Liquiñe-Ofqui Fault Zone (LOFZ). The GPS vector pattern of the Southern Andes seems to support this view. West of the LOFZ, GPS sites indicate uniform NE-directed velocities co-linear with the obliquity in plate convergence on the order of several centimetres per year, indicating that the plate interface is currently locked. East of the LOFZ, GPS velocities diminish abruptly to a few millimetres per year with a west-directed motion. At 36°S, GPS vectors change from NE-directed to SE-directed velocities. The observed GPS velocity field is widely believed to be caused by post-seismic mantle relaxation following the 1960 Valdivia earthquake.

We examine the cause for the observed upper-crustal kinematics by comparing the GPS vector field with the displacement vector fields obtained from 3-D digital image correlation of scaled analogue experiments using the MultiBox. In particular, we consider the influence of orogen-parallel variations in the strength of the upper model crustal on the surface displacement vector field. For this purpose, two-layer models are designed using a

3 cm thick layer of a silicone-corundum mixturemodelling the viscous lower crust and variable thicknesses of quartz sand portraying theMohr-Coulomb rheology of the brittle upper crust.

The MultiBoxconsists of two halves, each of which contain a piston, whereby one halve is mobile and moves relative to the fixed one parallel to the box midline. Each horizontal piston is fitted with a short vertical L-shaped baseplate. This piston geometry carries a portion of the overlaying silicone and sand layers and, thus, avoids unwanted localization of deformation at the pistons. A 20 cm wide area between the L-shaped pistons, in which material is detached from the base plate of the box allows for evenly distributed deformation and represents the actual Andean mountain range.



Analogue modelling results suggest that orogen-parallel strike-slip faults do not account for the GPS vector field in a compression-dominated transpressive setting, such as in the Southern Andes. The experiments point to the importance of the development of rhomb-shaped structural and topographic domains bound by oblique reverse faults in accomplishing orogen-scale transpression. The orogen-parallel change in upper crustal-strength is conducive for the development of such domains and can explain the regional variation in the GPS vector field. Comparison with field observation, geodetic data and the GPS vector field support the model observations.

Quaternary deformation at the Lerma Valley, Northwestern Argentina

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Northwestern Argentina is a seismically active, intraplate region on the back-arc of the Central Andes. Several intermontane valleys record paleo- and historical seismic events, as is the Lerma Valley in the Eastern Cordillera (Salta province). Geological studies in progress in the southern part of the valley focused on the Quaternary morphostructures and its sedimentary infill reveals evidence (synsedimentary deformation) for widespread paleoseismic activity during the Late Pleistocene-Holocene. At the same time, the records of a 13-months-running seismic network in the northern part of this valley, reflect the seismic activity in real-time. Combining both geophysical and geological studies will be suitable for unraveling the most recent deformation history in this part of the Andean deformation front that is characterized by irregularly distributed evidence of Quaternary to recent deformation throughout the Eastern Cordillera. In this context, the Medeiros anticline at the northern part of the Lerma valley, is interpreted as an active structure that must be deeply investigated due to its closeness to Salta city with more than 700,000 inhabitants.

This work was supported by PUE IBIGEO (CONICET), StRATEGy program (DFG-CONICET), CIUNSA 2336 and PICT-1928 (ANPCyT, Argentina). Owners from the Lerma Valley are thanked for the permissions to host the seismic stations during the 2017-2018 period.

Insights on the late Cenozoic evolution of the Rio Grande foreland basin in South Mendoza province, Argentina

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This study presents first results to reconstruct deformation and exhumation of the Andean mountain ranges between 34°S and 39°S from late Cenozoic to the present. The evolution of the Andes can be deciphered through the analysis of its adjacent depocenters, where synorogenic deposits and growing strata are found. These deposits record phases of rock uplift caused by shortening and exhumation or extension.

We investigate the Río Grande foreland basin, which relates to the generation of the Malargüe fold and thrust belt. The basin is located in the northern part of the Neuquina basin. Recently, the area has gained economic interest from the oil industry and the exploration of unconventional reservoirs. Primarily, this foreland basin was filled with epiclastic, volcaniclastic, and volcanic deposits, as well as fluvial and lake system sediments. Updated seismic information and borehole data from the subsurface shows that Pliocene and Quaternary deposits are folded by a series of east-vergent thrusts. This corresponds to the first evidence of recent deformation that shows the integration of the late Cenozoic deposits in the accretionary wedge of the Malargüe fold and thrust

belt construction.

We collected new data during a field campaign to build stratigraphic columns for a regional correlation and combination with available seismic data. We took samples from key places for a better coverage of the area. In addition, samples from borehole have been acquired and will be analyzed to integrate the outcrop and subsurface information.

Furthermore, to better constrain the Late Cenozoic tecto-sedimentary evolution of the area, we will use three different methodologies. First, sedimentation rates and depositional ages will be characterized by correlating outcrop samples to the interpreted seismic horizons, using U-Pb dating for minimum depositional ages. Second, this analysis will be complemented with petrographic studies in sandstone thin sections for a complete provenance study. Third, we started to work on the tectonic reconstruction of the study area using available and newly data to integrate the last deformation phase with the tectonics and sedimentation known in the area.

Finally, we will determine periods of sediment bypass from the Andean foreland basin towards the Colorado offshore basin by comparing periods of sedimentation and non-deposition or erosion in the different basins from the source region of sediments in the mountains to their sink region in the Atlantic Ocean. In this approach, we will relate the Central Andes growth to sedimentation in the foreland and offshore basins, in a „Source to Sink" concept, to elucidate the interaction between the Andean uplift, erosion, sediment transport and deposition in the Argentinian offshore.

This project is supported by the International Research Training Group StRATEGy, funded by the German Science Foundation.

Late Pleistocene to Recent shortening rates in the broken foreland of NW Argentina: New observations from the intermontane Cafayate Valley, 26° S lat.

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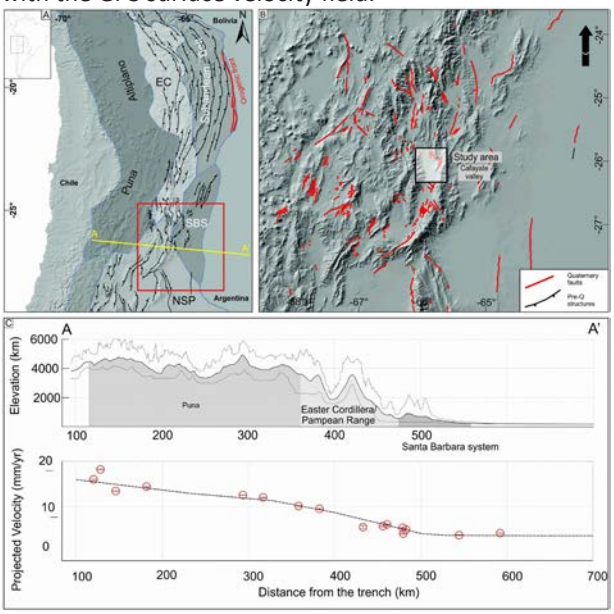
In thick-skinned broken forelands, localized uplifts typically occur in areas where retroarc convergence is mainly accommodated along re-activated high-angle structures. This reactivation typically occurs in a highly disparate manner, in time and in space (Strecker et al; 2012). These features also characterize the foreland of the Central Andes of NW Argentina. In this study, we evaluate how Quaternary deformation in the broken foreland is accommodated on millennial time scales. We assess the late Pleistocene to Recent tectonic evolution with special emphasis on shortening rates in the Cafayate intermontane basin of the Eastern Cordillera and compare them with the GPS surface velocity field.



A) Morpho-geological province of the central Andes (EC, NSP and SBS; Eastern Cordillera, Northern Sierras Pampeanas and Santa Bárbara system, respectively). B) Distribution of Quaternary faults in the broken foreland, compiled by Casa et al., (2014). The white square shows the study area. C) Profile view (A-A') of the surface velocity field projected perpendicular to the strike of the main East Cordillera structures, and on top Swath profile 50km wide. The profile shows in red the main velocity of each of the stations over the distance from the trench. Note that the velocities decrease gradually towards the East.

Our new structural data shows that the Quaternary deformation in the Cafayate basin is mainly located inside the valley rather than along the principal range-bounding faults that delimit the basin. We infer that faults and associated folds are linked with a thin-skinned detachment horizon in the Quaternary valley fill. The strike and vergence of the Quaternary faults are very similar to the basin-bounding structures. Shortening rates based on dated lacustrine and alluvial-fan sediments range from 0.5 to 5.66 mm/yr. The obtained velocity field profile for NW Argentina reveals that velocities decrease gradually from west to east. Taken together, our Quaternary shortening rates spanning different time scales suggest that deformation in the Eastern Cordillera is accommodated by widely distributed faults with variable shortening rates, pointing to strain release through numerous minor structures.

Reference

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Rupture directivity and stress drop estimation at the Northern Chilean subduction zone.

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The Northern Chilean subduction zone is a highly active region of intense seismic activity. For many years it has been well monitored by the Integrated Plate Boundary

Observatory Chile (IPOC) network. In this study we analyze seismicity from a time period of 2008 to 2016 using the broadband recordings (100Hz sampling rate) of the IPOC to infer earthquake rupture directivity and stress drops based on an empirical Green"s function (EGF) approach.

The elegance of using this approach lies in the low number of assumptions necessary for its application. However, the inevitable condition is the availability of EGFs for an event of interest. Using a cross correlation detector to identify highly similar waveforms between events we obtain EGFs for over 700 events. Out of these we find clear unilateral direction signatures for 293 events. The ensemble of directivity solutions displays a strong preference of rupture orientations sub-parallel to the convergence vector of the Nazca plate relative to the South-American plate. The preferred rupture direction is down-dip.

Alongside the rupture directivity estimation we compute earthquake stress drops for the same data set using the spectral ratio method which is also based on suitable EGFs. We test an integration of the information obtained by the directivity analysis into the stress drop estimation to reduce uncertainties. The resulting stress drop estimates indicate that the high slip regions of the 2014 Mw8.1 Iquique megathrust event are dominated by lower than average stress drops, while patches of events at the outline of the slip contour show higher than average stress drops.

Based on our results we speculate that the reason for the dominating rupture direction could be connected to the influence of a material contrast at the subduction interface and we hypothesize that the areas of high stress drop could constitute barriers which may have confined the megathrust event rupture area.

Processes culminating in the 2015 phreatic explosion at Lascar volcano, Chile, monitored by multiparametric data

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Small steam-driven volcanic explosions are common at volcanoes worldwide but are rarely documented or monitored; therefore, these events still put residents and tourists at risk every year. Steam-driven explosions also occur frequently (once every 2-5 years on average) at Lascar volcano, Chile, where they are often spontaneous and lack any identifiable precursor activity. Here, for the first time at Lascar, we describe the processes culminating in such a sudden volcanic explosion that occurred on October 30, 2015, which was thoroughly monitored by cameras, a seismic network, and gas (SO2 and CO2) and temperature sensors.

Prior to the eruption, we retrospectively identified unrest manifesting as a gradual increase in the number of long-period (LP) seismic events in 2014, indicating an augmented level of activity at the volcano. Additionally, SO2 flux and thermal anomalies were detected before the eruption. Then, our weather station reported a precipitation event, followed by changes in the brightness of the permanent volcanic plume and (10 days later) by the sudden volcanic explosion. The multidisciplinary data exhibited short-term variations associated with the explosion, including (1) an abrupt eruption onset that was seismically identified in the 1-10 Hz frequency band, (2) the detection of a 1.7 km high white-grey eruption column in camera images, and (3) a pronounced spike in sulfur dioxide (SO2) emission rates reaching 55 kg sec-1 during the main pulse of the eruption as measured by a mini-DOAS scanner. Continuous CO2 gas and temperature measurements conducted at a fumarole on the southern rim of the Lascar crater revealed a pronounced change in the trend of the relationship between the carbon dioxide (CO2) mixing ratio and the gas outlet temperature; we believe that this change was associated with the prior precipitation event. An increased thermal anomaly inside the active crater observed through Sentinel-2 images and drone overflights performed after the steam-driven explosion revealed the presence of a fracture ~50 metres in diameter truncating the dome and located deep inside the active crater, which coincides well with the location of the thermal anomaly. Altogether, these observations lead us to infer that a lava dome was present and subjected to cooling and inhibited degassing. We conjecture that a precipitation event led to the short-term build-up of pressure inside the shallow dome that eventually triggered a vent-clearing phreatic explosion. This study shows the chronology of events culminating in a steam-driven explosion but also demonstrates that phreatic explosions are difficult to forecast, even if the volcano is thoroughly monitored; these findings also emphasize why ascending to the summits of Lascar and similar volcanoes is hazardous, particularly after considerable rainfall.

Full-waveform inversion for seismic velocity and moment tensor solutions beneath North Chile

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We present a new seismic tomography model including radial anisotropy based on Multiscale Full Seismic Waveform Inversion for the crustal and upper-mantle structure beneath northern Chile, which is a part of the Nazca-South America Plate boundary known for frequent megath- rust earthquakes and volcanos. The forward and adjoint simulation based on a 3D model are accomplished with Salvus, which is a suite of spectral-element method solver of the seismic wave equation and of its adjoint, working in 2D and 3D tetrahedral, hexahedral, quadrilateral and triangular meshes. We perform the inversion running on the Piz Daint, hosted by Swiss National Computing Centre and invert waveforms from 78 events which are carefully selected for good coverage of the study region and depth range, yielding in total 6854 event-station pairs, 74% of which have effective time windows for full-waveform inversion. In order to mitigate the risk of convergence towards local minima, we divide the whole inversion procedures into three different time-period stages (40-80 s, 30-80 s and 20-80 s). The starting model is retrieved from the Collaborative Seismic Earth Model (Fichtner et al., 2018) and we proceed the inversion from lower to higher frequency bands. We take advantage of the adjoint methodology coupled with conjugate-gradient and L-BFGS optimization scheme to update the seismic velocity model. Through full-waveform inversion, we effectively improve the resolution of the current model. The most conspicuous feature is the strong radially anisotropy for S wave velocity: the Vsv and Vsh within the subducted slab demonstrate an obvious different strength and shape.

Meanwhile, in order to alleviate the effect of inaccuracy of earthquake source parameters, in particular depth, on the seismic velocity model inversion and to update the moment tensor catalogue, we implementeded a seismic source inversion workflow based on Greens“ Functions calculated for 1-D and 3-D seismic velocity models. We take a consecutive way to update our Greens“ functions based on the updated Seismic velocity model from our adjoint inversion com- bined with the high-frequency analytic Greens“ functions based on 1-D model for incorporating more body wave phases.

Kinematically heterogeneous faulting in the configuration of Neogene Patagonian foreland basins: activation of pre-existing fabrics and strain partitioning

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The retroarc of the North Patagonian Andes was configured by the uplift of basement blocks limited by faults strongly oblique to the Andean chain. These fault systems defined the Patagonian Broken Foreland, characterized by a series of Neogene basins distributed along the reatroarc system. Several interpretations about the origin of this tectonic scenario have been devised in recent years. On the one hand, a partitioning of deformation is proposed as the main control in the configuration of the main cordillera and the foreland zone as a result of oblique convergence between Nazca y South America plates. Contrarily, reactivation of Paleozoic and Mesozoic crustal anisotropies was suggested to explain the configuration of thick-skinned-dominated tectonics during the last contractional Andean orogeny phase. Nevertheless, detailed studies that tested the relationship between the Paleozoic and Mesozoic crustal weaknesses with Andean structures have not yet been developed. This uncertainty determines an ambiguous tectonic framework in which kinematic analysis is absent.

The Sañicó Massif presents uplifted basement blocks with well-exposed fault zones associated with a thin record of intermontane basin infill. The work was carried out based on morphostructural and microstructural studies of pre-existing basement fabrics and the Andean structures. The basement fabrics (regional metamorphic foliation and ductile shear zones) present a close location and geometric relationship with all extensional Mesozoic and Andean faults. Kinematic results of small-scale faults show heterogeneous patterns due to the interaction of pre-existing fabrics reactivation, multiple deformations and subgroups of new faults.

The results indicate a three-dimensional deformation model in the foreland zone, fundamentally controlled by the activation of Paleozoic basement fabrics and tectonic inversion of Mesozoic extensional faults. In turn, the small-scale structures present a heterogeneous distribution, which could be linked to the response of convergence direction. Although the results demonstrate a strong control of pre-existing weaknesses, mechanical models of deformation that reproduce the observed kinematic model, can provide insight into the natural conditions of deformation. Hence, analogue models will represent a functional tool for testing the influence of structural inheritance as well as, the progressive deformation undergone during different tectonic conditions.

Slab hydration: combining constraints from oceanic plate structure and intraslab seismicity

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Most subduction-zones exhibit two bands of intraslab seismicity, the lower one situated at 20-40 km below the plate-interface within the subducting oceanic mantle. This band, which is usually referred to as the lower

seismicity plane, runs parallel to the plate-interface and is characterized by rather low magnitude earthquakes showing downdip-extensive mechanisms. The intensity of lower-plane seismicity often varies greatly along a single subduction zone, and can be completely absent in some areas. To date, there is no single accepted physical model which explains the mechanism that drives earthquake occurrence within the lower-plane as well as observed spatial variations over relatively short distances. One hypothesis that has been put forward for explanation of the existence of the lower seismicity plane is that it results from serpentinite dehydration along the 600–650□C isotherm in the oceanic mantle. Serpentinization possibly occurs in the outer rise region of oceanic trenches by water which infiltrates the oceanic crust and mantle along bending-related faults. If this hypothesis is correct, the intensity of lower-plane seismicity should correlate with the amount and penetration depth of water in the slab, and thus with the intensity and the depth extent of bending-related faulting. To test this, we correlate the occurrence and intensity of lower-plane seismicity in the North Chilean, Japan Trench, and Central American subduction-zones with oceanic-plate fault patterns in the outer rise and trench regions. To analyze the intensity of lower-plane seismicity, we compute the ratio between event numbers in the rather homogeneously active upper seismicity plane and the lower plane in along-strike distance bins. With this approach, we avoid the issue of variable earthquake catalog completeness that would complicate the analysis if absolute event numbers were used. Fault patterns are derived from a compilation of more than 100 ship-based bathymetric surveys complemented by published seismic reflection lines which run perpendicular to the individual margins. First results point towards a higher rate of lower-plane seismicity in regions where plate-bending is expressed in well-developed horst-and-graben structures as well as in regions where topographic features on the oceanic-plate enter the subduction-zone. Future work will further explore this possible correlation.

Interplay between constructive deep mechanisms building the Central Andes and the stress field

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Both in continental collision and subduction-related orogens, different kinds of mega-detachments have been proposed to explain the horizontal shortening, crustal thickening and topographic uplift. In fold-and-thrust belts, these detachments have traditionally been located inside levels of mechanical anisotropies. These orogenic wedges thicken towards the hinterland, reaching depths located in the brittle-ductile transition. At an orogenic scale, these shear zones are not controlled by frictional sliding, but rather by temperature, composition, strain rate, and the stress field. While the synergies between crustal deformation, exhumation and sedimentation processes are well-known to a first order, it is challenging to evaluate the interplay between constructive deep mechanisms and the in-situ stress field. Two outstanding questions in the study of orogenic processes are: How does shallow structures in the foreland fold-and-thrust belt connect with ones in the hinterland under an evolving and changing stress field? How long can a detachment remain active during an orogenic event?

To answer these questions, we use the Central Andes as a natural laboratory and construct kinematic-thermomechanical models for the last episode of crustal deformation and thickening. Our models show that a shallow, sub-horizontal megadetachment located at the shallowest brittle-ductile transition concentrates most of the horizontal crustal shortening between the fore-arc and the South American craton. We propose that, locally, a threshold in horizontal shortening and crustal thickening is achieved when the buoyancy force equals the horizontal force, and at this point, the mega-detachment deactivates, and the crustal root widens eastwards, in concert with ductile deformation in the lower crust and the generation of a new mega-detachment. Our working hypothesis is that, by studying changes in the paleostress fields along the arc region, together with the timing of uplift and exhumation of the morpho-structural units across the transects, we can constrain the timing of activation/deactivation of the detachments responsible for the Andean deformation. We suggest that a change in the stress field from compression to strike-slip regime can be used as a proxy for the deactivation of a mega-detachment.

For this purpose, the temporal and spatial stress field variations is used as a parameter crucial to understanding the relationship between deep and shallow crustal deformation

Interplay between salt tectonics and gravitational extension tectonics in the Sureste Basin, Mexico

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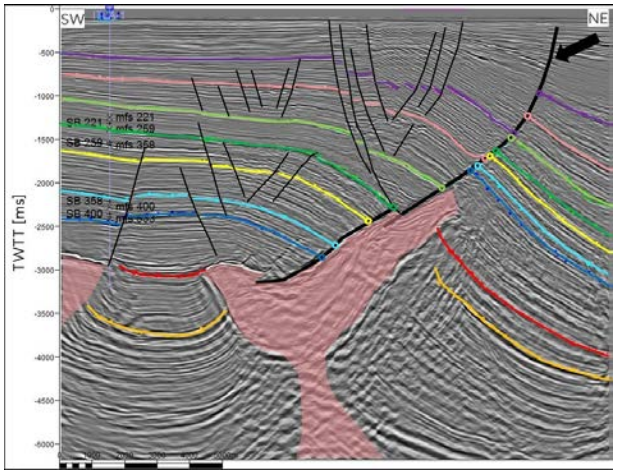
The structural evolution of salt diapirs is a key aspect which needs to be understood when exploring for hydrocarbons in salt basins. Structural traps often exist at flanks and on top of salt diapirs as well as along faults re-

lated to salt diapirs. The development of salt diapirs also has a major influence on sedimentation with phases of vertical salt movement usually related to non-deposition of sandstone reservoirs on top of salt diapirs but with sandstone fairways mainly located in mini-basins in between salt diapirs. The structural evolution of salt diapirs has therefore important implications for reservoir deposition and for the migration history of hydrocarbons.
In this study we investigate the detailed tectonic evolution of one salt diapir and a gravitational extension fault located in the Sureste Basin in the southern Gulf of Mexico. The analysis is based on 3D seismic data and wells near the salt diapir. Salt interpretation is done on seismic data with the top of salt readily identifiable. Flank and feeder of the salt diapir have less reliable interpretations due to poor seismic imaging close to the salt diapir. The interpreted salt diapir geometry is very complex with a deformed diapir shape and normal faults atop (see figure 1). A large listric normal fault, which offsets the seabed, passes into the diapir and several active antithetic faults also exist above the salt diapir.
The development of normal faults in the vicinity of the salt diapir was analysed using fault displacement methods. For this purpose, displacements along the fault surfaces were measured on late Neogene horizons. Backstripping of displacements then allowed the reconstruction of the fault development through time (Childs et al. 1993).



For the development of the salt diapir, detailed biostratigraphic analysis is used to determine the ages of identified hiatuses and condensed sections. Several condensed sections observed in wells can be correlated with local unconformities near the salt diapir identified on seismic data. Unconformities near the salt diapir are interpreted to reflect vertical movements of the salt diapir. Detailed mapping of thickness changes and dating of unconformities is therefore used to reconstruct the temporal evolution of the salt diapir.

The combination of unconformity and fault displacement mapping was used to decipher the interplay between salt diapir development and gravitational normal faulting. The results of the study indicate that Neogene activity of the salt diapir mainly occurred during Early to Late Miocene times. Normal faulting started in the Pliocene and resulted in the development of a large listric counterregional normal fault and associated antithetics. Normal faulting is still ongoing and it is assumed that extension accommodated by gravitational normal faults in the Pliocene to Recent section is balanced by widening of the salt diapir at depth.

Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the Argentine passive continental margin

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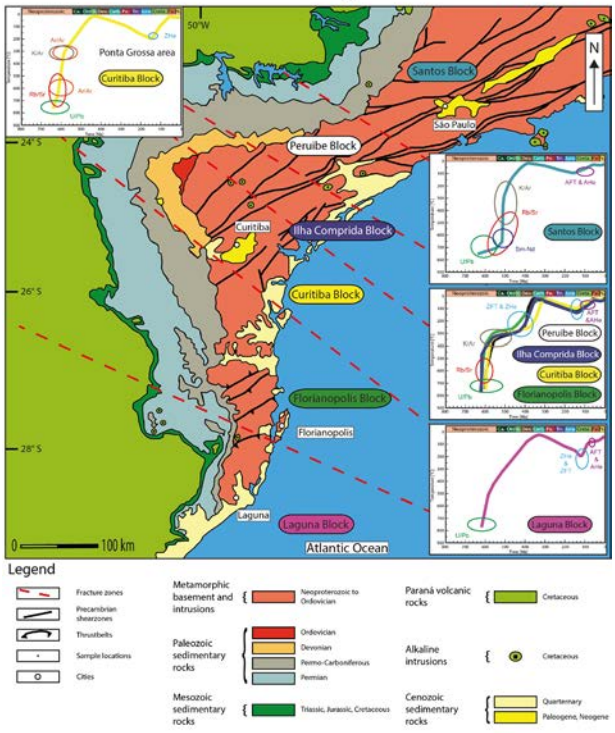
Passive continental margins are geo-archives that store information from the interplay of endogeneous and exogenious forces related to continental rifting, post-breakup history, and climate changes. The recent South Atlantic passive continental margins(SAPCM“s) in Brazil, Namibia, and South Africa are partly high-elevated margins (~2,000 m a.s.l.), and the recent N-S-trending SAPCM in Argentine and Uruguay are of low elevation. In Argentine, an exception in elevation is arising from the higher topography (> 1,000 m a.s.l.) of the two NW-SE-trending mountain ranges Sierras Septentrionales and Sierras Australes. Precambrian metamorphic and intrusive rocks, and siliciclastic rocks of Ordovician to Permian age represent the geological evolution of both areas. The Sierras Australes have been deformed and metamorphosed (incipient - greenschist) during the Gondwanides Orogeny. The low-temperature thermochronological (LTT) data (< 240 °C) indicated that the Upper Jurassic to Lower Cretaceous opening of the South Atlantic has not completely thermally reset the surface rocks. The LTT archives apatite and zircon still revealed information on the pre- to post orogenetic history of the Gondwanides and the Mesozoic and Cenozoic South Atlantic geological evolution. Upper Carboniferous zircon (U-Th/He)-ages (ZHe) indicate the earliest cooling below 180°C/1Ma. Most of the ZHe-ages are of Upper Triassic to Jurassic age. The apatite fission-track ages (AFT) of Sierras Septentrionales and the eastern part of Sierras Australes indicate the South Atlantic rifting and, thereafter.

Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the SE coastal region of Brazil



AFT-ages of Middle to Upper Triassic on the western side of the Sierras Australes are in contrast, indicating a Triassic exhumation caused by the eastward thrusting along the Sauce Grande wrench. The corresponding t-T models report a complex subsidence and exhumation history with variable rates since the Ordovician. Based on the LTT-data and the numerical modelling we assume that the NW-SE-trending mountian ranges received their geographic NW-SE orientation during the syn- to postorgenetic history of the Gondwanides.

Distributed transpressive deformation in the Southern Andes: Insights from low-temperature geochronology and DEM-analysis

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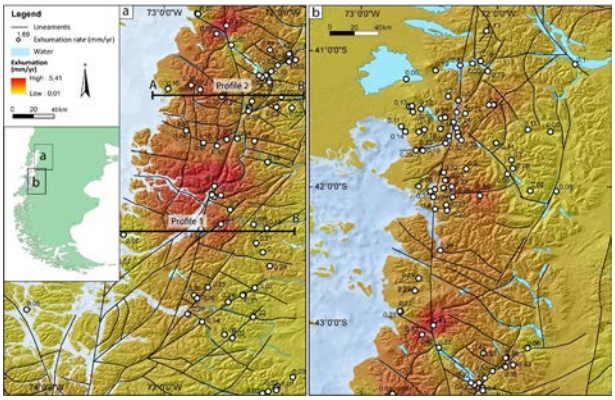
Models of intra-arc deformation in the Southern Andes commonly focus on displacement along the Liquiñe-Ofqui Fault Zone (LOFZ), which cuts the modern Andean volcanic arc along-strike for more than 1000 km. In accordance with the oblique plate convergence, northward displacement of the Chiloé Block, apparently a detached forearc sliver, has been interpreted as evidence for an overall dextral displacement on the LOFZ. In the context of this tectonic framework, which is poorly supported by kinematic ground truth, the LOFZ is commonly regarded as the main or only discontinuity to accommodate deformation in the volcanic arc. Recent paleomagnetic and kinematic studies, however, provide independent evidence for distributed deformation along a number of additional first-order faults resulting in heterogeneous vertical axis rotation of rocks. Following these studies, we highlight the complexity of deformation in the Southern Andes and discuss the role of the LOFZ in the tectonic setting by means of detailed lineament analysis in combination with a reassessment of published kinematic and thermochronological data.

Lineaments presented in this study were extracted from shaded relief models, drainage models and aspect maps derived from ASTER GDEM 2 high-resolution digital elevation models. Apatite fission track and U/Th-He ages were used to model exhumation rates, which were subsequently interpolated using an inverse-distance weighting method. Between 42° S and 47° S, DEM-analysis reveals a network of interconnected lineaments trending predominantly N-S, NE-SW, and NW-SE, a number of which displaying mutual offsets. Thermochronometry data show enhanced exhumation in the central cordillera where drastic changes in exhumation rate spatially coincide with the intersection of lineaments. Here, individual fault-bound blocks display specific exhumation rates.



In contrast to the common, rather crude perception of intra-arc deformation in the Southern Andes, results of our work, in line with most recent studies, require reconsideration of the kinematic model. Most importantly, deformation appears to be distributed across the entire width of the Southern Andes, and the fore-arc sliver is displaced on a network of structural discontinuities, rather than merely on the LOFZ. Moreover, variations in exhumation rates of individual fault-bound blocks call for significant vertical displacements during deformation. Collectively, results of this study indicate a rather uniform deformation of the entire Southern Andes as a result of oblique convergence.

Lithospheric temperature and rheology of the North Patagonian Massif plateau, Argentina.

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The North Patagonian Massif (NPM), in central Argentina, includes a plateau of an average altitude of 1200 m.a.s.l. mostly surrounded by basins that stand between 500 to 700 m below it. Geological observations and previous works indicate that the present-day elevation of the plateau was reached in the Paleogene by a sudden uplift that did not involve noticeable deformation. To gain insight into the causes of the uplift and the geodynamic development of the area, it is necessary to characterize the lithosphere in terms of its present-day physical properties.

In this study, we present models of the three-dimensional lithospheric distribution of temperature in the area, as well as, of the maximum differential stress that the rocks are able to resist without experiencing either brittle or ductile deformation under given pressure and temperature conditions. For the thermal calculation, we used the software GOLEM and, in the case of the strength calculations, a code that resolves Byerlee"s law for the brittle part and power-law rheology functions for the ductile one. We use as a base for the models, an existing gravity constrained 3D geological model that was developed in a previous project. It includes all available geological and geophysical information to constrain the geometries and the lithologies of the model units and was compared to the observed gravity to obtain the depth of the Moho. By using the model configuration, we assigned to each unit corresponding thermal properties to calculate the thermal field and afterwards also parameterized the model in terms of mechanical properties to obtain the strength distribution within the lithosphere.

With this contribution, we present a comparison between the model derived physical properties inside the plateau with those obtained for the surrounding areas. The predicted present-day temperature and strength differ significantly from one region to the other, differentiating the NPM plateau in terms of these characteristics. This analysis helps to test hypotheses on the influence of the temperature and strength distribution in the geodynamics of the region and brings up for discussion the causes of the formation of the plateau and its present-day elevation.

3D density structure of the Caribbean lithosphere derived from Vertical Gravity Gradients: Implications for regional tectonic boundaries and the characterisation of geohazards

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The oceanic lithosphere is one of the less well-known features of the outer Earth. Here, we propose a new method for inferring the density of the crystalline crust and delimiting its tectonic boundaries at the crustal level. As a novelty, instead of modelling the gravity anomalies and assuming a flat Earth approximation, we model the Vertical Gravity Gradients (VGG) in spherical coordinates. The methodology is validated in the oceanic domain of the Caribbean region.

First, we defined a lithospheric starting model constrained using up-to-date geophysical datasets, including: seawater, sediments, crystalline crust and mantle down to a depth of 200 km. After testing several a-priory density distributions, calculating their VGG response, we selected the model with the minimum RMSE (Root Mean Squared Error) with respect to EIGEN-6C4 dataset. In this model, the density of the seawater, sediments and mantle was calculated in 3D using existing empirical formulations. Second, we inferred the density of the crystalline crust by inverting the VGG field. This methodology allowed us to obtain a 3D density distribution for all the layers of the Caribbean lithosphere.

Additionally, based on the gradient‘s residuals (EIGEN-6C4 measurements minus modelled results), we identified crustal features such as high-density bodies located in the forearcs of the Lesser and Leeward Antilles. Finally, we proposed and/or confirmed important tectonic boundaries in regions such as Yucatan, Colombian, Venezuelan and Grenada basins, including the Continental-Oceanic Boundary in the study area (Figure 1).

The South Caribbean is particularly prone to different geohazards, including earthquakes and tsunamis. This margin is characterised by the flat-slab subduction of the Caribbean plate under the continental South American plate. The hazard risk assessment in the region has been mainly assessed considering the tectonics and seismicity; however, tsunamis can also be triggered by the destabilisation of gas hydrates deposits, especially in river-dominated margins, such as the South Caribbean region.

The knowledge of the thermal distribution in subduction systems can be used as a proxy for the delimitation of the width of the seismogenic zone, taking advantage of the stick-slip behaviour that rocks at subduction zones

show, especially between 150°C and 350°C. Meanwhile, gas hydrates are stable in low-temperature and high-pressure environments, normally found in marine sediments within continental slopes, with dominant temperatures ranging from 5°C to 10°C, at depths greater than 400 m.

Currently, we are developing the first 3D thermal model of the South Caribbean margin, using the obtained 3D lithospheric density distribution. The expected results include an evaluation of the seismogenic zones, and a preliminary characterisation of the gas hydrate stability zone (GHSZ) in this tectonically active and complex region.

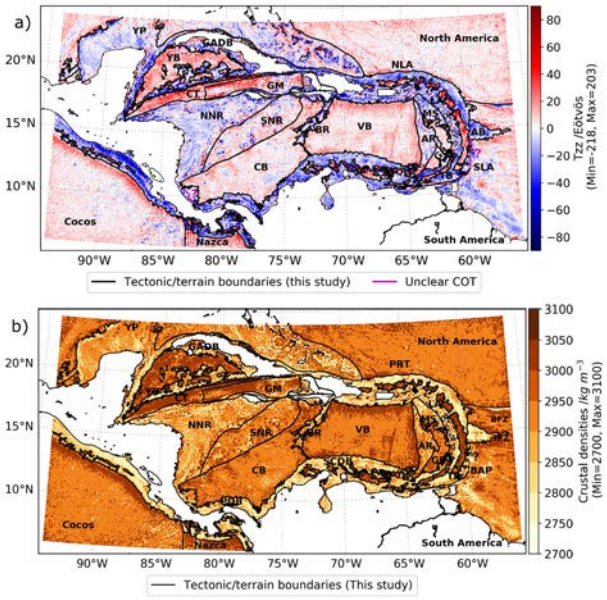

Figure 1. a) Residuals of the VGG and the tectonic and terrain boundaries refined, proposed or confirmed in this study. Color scale saturated at -90 and +90 Eötvös. b) Average crustal densities inferred from the forward modelling of the VGG.

Seismic structure and tectonics of the north Chilean convergent margin between 19ºS and 21ºS using multichannel seismic reflection data

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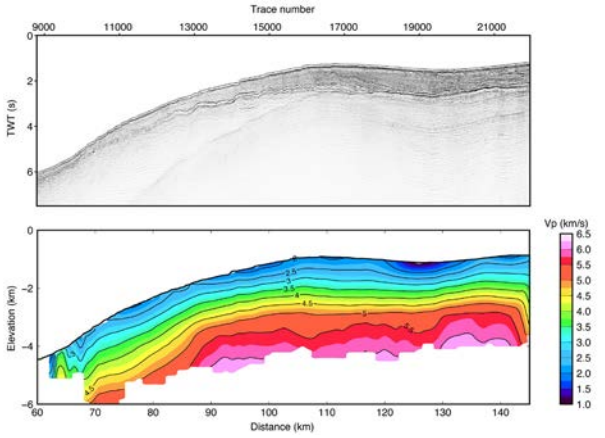
The convergent margin of north Chile is widely recognized as an erosive subduction zone due to the lack of sediment contribution from the continent and evidenced by a landward migration of the volcanic arc during the past 100 Myr, frontal and basal erosion, subsidence, among others. There is also a well-studied seismic gap, where no major earthquakes (Mw>8.5) have occurred since 1877. Although some studies have been developed in the past years regarding the geologic and seismic structure of the margin and its tectonic implications, there are still some features of the structure and tectonic scheme that remain uncertain or unknown in the regional and local context.



This study is part of the PICTURES (Pisagua/Iquique Crustal Tomography Improves Understanding of Region of the Earthquake Source) project, which main goal is to understand the role that features and geologic structure of the upper plate played on the occurrence of the 2014 Mw 8.2 Pisagua/Iquique earthquake offshore northern Chile and, in general, the regional seismicity. Seismic reflection and refraction data were acquired during the MGL1610 cruise along a grid of 2D lines and recorded on ocean bottom seismometers to generate a 3D velocity model. In particular, the goal of this work is to analyze the variability of the margin structure along the north of Chile between 19 and 21ºS and its implications for the tectonic control and the seismicity. For this purpose, four ~150 km long W-E reflection lines are processed following a standard reflection seismic sequence. P-wave 2D velocity sections are also obtained following a travel time tomography inversion procedure using refraction time arrivals of the multichannel dataset, which allows to give a good spatial resolution for the shallow structure of the continental slope along the margin. Seismic and velocity sections are then interpreted together to give an image of the main features along the margin, especially for the shallow structure.

Understanding seismic and tsunami hazards in the Chilean subduction zone: lessons and perspectives from the framework of interdisciplinary studies

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The aftermath of the 2010 Mw 8.8 Maule Earthquake and the 2011 Mw 9.1 Great East Japan Earthquake brought to light a fragmentation that exists between science, stakeholders and community. New discoveries and observational methodologies from the earthquake and

tsunami sciences were not enough to diminish the impact of these two great earthquakes and their coupled tsunami events. As a consequence of these recent devastating tsunamis, Chile calculated 156 victims and Japan nearly 13,000. In order to avoid the future impact of natural disasters in Chile, in 2011 the National Science Foundation of Chile (CONICYT) launched a competitive call to create the first center for interdisciplinary studies of disaster risk reduction. This competitive application call was aimed to develop the scientific basis for an efficient and effective transference of the new knowledge of hazard-risk sciences to the public. After seven years in its development, CIGIDEN (National Research Center for Integrated Natural Disaster Management) has become a key component of the disaster mitigation strategy of Chile. CIGIDEN is a consortium formed by four Chilean Universities in which participate geoscientists, engineers, sociologists, psychologists, urban planners, journalists and anthropologists. In the present contribution we present key lessons for Disaster Risk Reduction Strategies learned from studying the most recent earthquakes, which occurred in Chile, the 2010 Mw 8.8 Maule Earthquake, the 2014 Mw 8.1 Iquique earthquake and the 2015 Mw 8.3 Illapel Earthquake. We reviewed the most important scientific milestones, which have been developed with an interdisciplinary perspective for disaster risk reduction. Key aspects revisited in this contribution are: How to generate earthquake scenarios using the existing observation methodologies in subduction zones. What are the key parameters of earthquake scenarios for substantial tsunami impact reduction. What is the role of coastal geomorphology for assessing tsunami impact. What are the still pending aspects in reducing the number of tsunami victims. How we can efficiently and effectively transfer hazard science to stakeholders and communities.

Ages and internal structure of plutons in the Dominican segment of the Caribbean Island Arc

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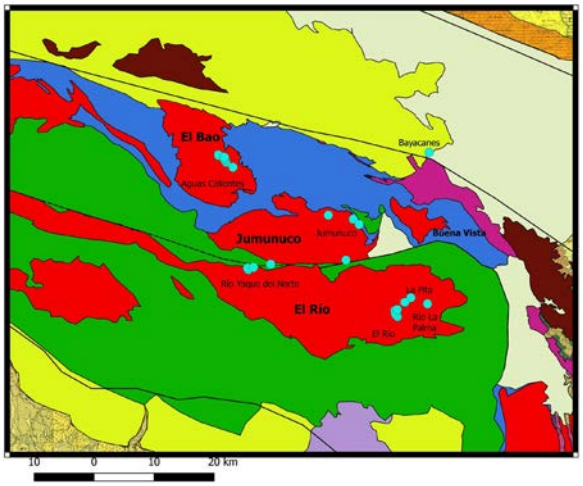
One of the main processes governing the crustal evolution of the Caribbean is the magmatic activity of the Great Caribbean Island Arc. On the Greater Antilles, the Cordillera Central of Dominican Republic is one of the outcrop areas for studying the plutonic basement of the Caribbean Island Arc. We present zircon U-Pb ages of 18 rock samples from the El Río, El Bao and Jumunuco plutons. The samples range from diorites to peraluminous granite with the majority being tonalites. The results show a contemporaneous emplacement of the three intrusions in the midst of the Cordillera Central between 90 and 80 Ma. However, ages of the El Bao pluton overlap at about 86 Ma, whereas the rocks of El Río and Jumunuco pluton display a wider range. In the El Río pluton, the biggest and structurally most complex of the three studied intrusions, the measured zircon ages are in agreement with the relative age relations observed in the field.



The main sequence of intrusion is marked by early tonalites that are later followed by younger granodiorites and granites and approximately concurrent dioritic rocks. Besides, the distribution of ages throughout the El Río pluton points to an early emplacement of tonalites in the northern part and subsequent intrusion of magmas to the south. The ubiquitous occurrence of mixing and mingling structures between mafic and felsic rocks and the lack of a correlation between zircon age and differentiation indices point to a continuous replenishment of magma reservoirs in the studied intrusions. The occurrence of voluminous plutons of ages between 90 and 80 Ma in the Cordillera Central constrains that the main activity of magmatism in the Dominican segment of the arc took place in this phase. The absence of inherited zircon older than 100 Ma furthermore indicates its nearly exclusive oceanic evolution in the Cretaceous. The ages of the dated rocks fall into the Upper Cretaceous phase of arc magmatism in the Great Caribbean Arc and are comparable to other intrusions along the Greater Antilles.

The Quaternary Payún Matrú caldera, andean back-arc of the Southern Volcanic Zone: insights into its caldera-forming eruption deposits

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The Quaternary Payún Matrú caldera is located in the back-arc of the Southern Volcanic Zone of the Andes,

western Argentina, and represents the main volcanic edifice of the Payún Matrú Volcanic Field (PMVF). The PMVF is located within Payenia, a volcanic province characterized by alkalic basaltic volcanism. The PMVF presents the homonym caldera along with the Payún Liso volcano and 220 basaltic monogenetic cones. Payún Matrú has a long-lived pre-caldera stage where a shield-like edifice has been built. The syn-caldera stage is represented by the Pleistocene Portezuelo Ignimbrite and the resulting caldera depression of 8.5 km in diameter. Afterwards the caldera event, volcanism continued mostly along the caldera rim.

We present stratigraphic sections, facies analysis and mineralogical studies of the Portezuelo Ignimbrite, in order to determine pre-eruptive conditions, onset of collapse and eruptive history of the caldera-forming eruption deposits. The extra-caldera Portezuelo Ignimbrite shows different facies, being most of them massive or eutaxitic and massive lapilli tuff facies, deposited by dense pyroclastic density currents. Fall deposits are found only restrained to the caldera margin, suggesting the lack of a sustained eruptive column at the onset of eruption. Massive tuff facies are found at the topmost deposits south of the caldera, and indicates the development of a co-ignimbritic plume as the pyroclastic density currents wanned. Four distinct juvenile clasts were recognized on the basis of color, shape, size, vesicularity and crystallinity. These are: gray fiamme, light gray pumice, dark gray pumice and black juveniles. Whole-rock chemical analyses of gray fiamme and black juveniles have a similar trachytic composition, while the mineralogical composition of juvenile clasts reveals some differences, specially in feldspars. On the basis of discontinuity surfaces and the juvenile clasts population of the ignimbrite, several eruptive units were defined. Given the absence of lithic breccias, the onset of collapse is suggested by a change in the juvenile clasts population in the topmost eruptive unit, which presents dark gray and light gray pumice together with black juveniles. The sequential appearance of different juvenile clasts suggests a zoned magma chamber, in terms of crystal content and mineralogical composition.

Andean exhumation and erosion across the Pampean flat-slab transition

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The temporal and spatial evolution of Andean orogeny between 30°S and 35°S during the Neogene is traditionally linked to the development of the Pampean flat-slab in the late Miocene. To a first order, the geographic coincidence of the Pampean flat-slab, topography, total crustal shortening and the west to east sweep of magmatism comes together in what appears to be appears to all but a foregone conclusion. Yet, a spate of recent studies including foreland basin deposits, bedrock and detrital thermochronology, cosmogenic nuclide-derived erosion rates and other geomorphic observations squarely call the simple flat-slab linked, eastward-stepping deformation model into question. Observations from a series of previously published studies, combined with new detrital thermochronology data make the case for spatially continuous rock uplift in the Frontal Cordillera and Precordillera prior to the onset of the flat-slab at in the Late Miocene. Data from cosmogenic nuclide concentrations of sediment in rivers that drain catchments throughout this segment of the Andes show overall higher erosion rates on the eastern flanks of the range despite steeper slopes and an order of magnitude increase in precipitation on the western side of the range. This result demonstrates that tectonically controlled rock uplift, not climate or vegetation, exerts a first order control on modern erosion rates in this segment of the Andes. On both sides of the Andes there is a prominent, and symmetric, spike peak in erosion rates centered at 33.75°S latitude, where catchment-wide erosion rates rates exceed 400 m/Ma. Extremely young, non-volcanic detrital zircon (U-Th/He) data from the Tunuyán and Arroyo Grande catchments, along with independently derived estimates of surface uplift strongly suggest this is not a transient signal confined to modern erosion rates. On the whole, our analysis supports the notion that more mass is fluxed through the eastern flank of the Andes, even south of ~33°S where the orogen narrows and crustal shortening abruptly decreases.

Palynofacies and maturity offshore Suriname – implications for the petroleum system

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Former DEA and their partners drilled an offshore exploration well located 120km off the Suriname coast in the Suriname-Guyana Basin. This passive, continental-margin-style sedimentary basin is considered to comprise all elements required for a promising hydrocarbon province. These Cretaceous to Tertiary aged successions are characterized by interbedded sands and shales, deposited in a variety of marine and non-marine environments, and marine carbonates.

In the present study the presence of an Upper Cretaceous petroleum system is tested with potential source rocks of Cenomanian to Turonian age and intercalated turbiditic sandstones. Besides detailed palynofacies information in terms of palaeoenvironment, the maturity is assessed by means of spore coloration index

(SCI) and vitrinite reflectance (VR). The studied interval stratigraphically stretches from the Paleocene to Middle Albian. 30 samples are considered for palynofacies analysis and 11 samples for vitrinite reflectance measurements. For the kerogen classification, palynofacies analysis, and SCI an inhouse classification system and procedures is applied. The slides for Vitrinite reflectance measurements are processed according to international standards (ICCP & ASTM D7708-14).

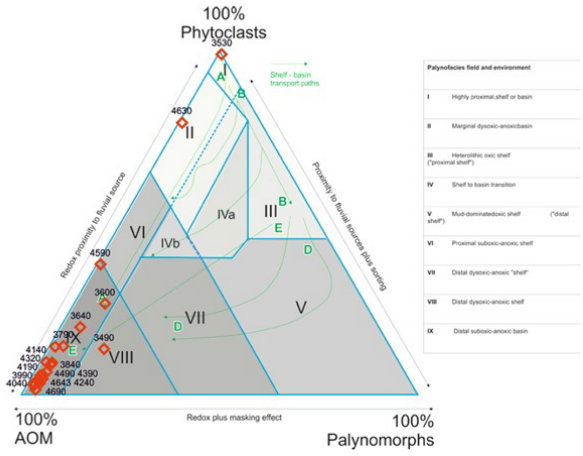

Figure: Ternary AOM – phytoclast – palynomorph diagram. The diagram allows to characterize kerogen assemblages considering the differences in relative proximity to terrestrial organic matter sources, kerogen transport paths and the redox status of depositional sub-environments which control AOM preservation. The examined samples are mainly placed in fields with anoxic conditions.

Nearly all samples show high percentages of amorphous organic matter (AOM). The samples mainly belong to kerogen type 2 (marine, liptinite rich) and partially to type 3 (input of terrestrial material). Most of the samples indicate marine, anoxic conditions with good preservation conditions for organic matter (Fig. #). In a neighboring well, the kerogen was also assessed type II and interpreted as a product of an upwelling system.

The thermal maturity measurement data indicate that all samples can be assigned to the oil window. They all yield only a small number of spores, resulting in a low level of confidence due to the low number of measurements. The small size of the vitrinite grains hamper the proper distinction between vitrinite and other macerals (inertinite and bituminite). Nearly all samples show two populations of measured VR values. It can be assumed that the population with lower values reflects measured values of bituminite.

Summing up, thermal maturity parameters and kerogen composition indicate, under the assumption that the TOC is high enough, a moderate hydrocarbon generation potential. Critical for the Upper Cretaceous petroleum system seems reservoir presence in form of mass transport deposits.

Into Amazonia: the history of the Amazon River and rainforest

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In this presentation I hope to take you with me on a journey that started in 1988 went I first visited the Amazon rainforest. My mission was to document the Tertiary at whichever outcrops I could find and perform palynological analysis of samples to get an insight into the history of the rainforest. My research started at Araracuara (Caquetá Province, Colombia), which means 'home of the macaws', however, this site also had a dark history, as it was a former penal colony for the most dangerous criminals from Colombia. Araracuara is situated along the Caquetá River, which cuts across Paleozoic and Neogene formations. The latter turned out to be a key to the puzzle of how the history of the Amazon and its rainforest unfolded. I will also introduce you to some of the research sites in Peru and Brazil, and even extend to the deep waters at the mouth of the Amazon, which forms part of my more recent research. The data collected and the collaboration with many great colleagues made it possible to lift a tip of the veil and discover some of the history of the Amazon. This story is still unfolding and future work can generate more knowledge on this endangered ecosystem.

GPR supported sampling for environmental purposes. Examples from te Rio São Francisco marginal lagoons, Minas Gerais, Brazil.

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The human occupation of the San Francisco basin, beginning with the economic wonder initiated by the Vargas e Kubitschek administrations, results in an increase of the impacts. From the beginning of the 20th century took place an intense use of the natural resources of the São Francisco River, like electricity production, fish creating, agriculture and heavy industry. The population multiplied in some years. All this economic important activities caused an immense and increasing impact on the river system. The natural and anthropogenic induced changes in the system are reflected in the sediment system of the marginal lagoons. Marginal lagoons are filled during the flooding of the river and together with wind transport, rain washout and interaction with subsurface water with sediment material. Therefore, marginal lagoons are an important for the knowledge of the evolution of a river system. To obtain representative profile sampling it is necessary to know the sediment, geological e dynami-

cal situation of the lagoons. To obtain information about sediment distribution and structures, GPR - profiles on lagoons are an adequate technique for rapid and exact results and permit to find easily appropriate locations for drilling and sampling. The structure of the obtained cores show a very good correlation with GPR results and permit an evaluation of the history of the lagoons.

The chemical features, mineralogical and grainsize distribution correlated with time permitted to obtain information about climate variations, like rainfall, vent directions, insolation and temperature evolution, and anthropogenic influence caused by human activities in the basin, like installation of power plants and its lakes, irrigation activities, installation of industrial plants and changes in land use and water related activities.

Observing the evolution of these parameters it is able to see changes from industry to agricultural sources, the increase of wastewater input and changes in the physical evolution of the river basin.

The sediment archive of the western Campeche Bank: From Chicxulub impact to Loop Current evolution

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The Cretaceous-Paleogene extinction event was responsible for the extinction of ~36% of known marine faunal genera and ~76% of known marine invertebrates. The Chicxulub asteroid impact on the Yucatan peninsula is most likely the sole cause of rapid global climatic and ecologic crisis. We here suggest that the Campeche Bank (also known as Yucatan Shelf or Yucatan Carbonate Platform) in the southern Gulf of Mexico (GoM), which is a classical carbonate ramp with no or little terrestrial influx, is affected by the Chicxulub event. At Campeche Bank the typical platform type with a gentle basinward dipping surface presumably developed due to the suppressed formation of photozoan carbonates in response to topographical upwelling.

We studied a prominent infilling drift on the western Campeche Bank by means of multi-channel reflection seismics, parametric subbottom echosounding, multibeam and sediment sampling during RV Meter expedition M94 in 2013 (see Figure). The seismic data show a headwall scarp and basal shear surface of a mass transport complex. We postulate that the shear surface is covered from ca. 100 ms TWT thick breccia resulting from the Chicxulub impact. If this interpretation is correct, the overlying strata comprise almost the entire Cenozoic succession. The main portion of the mass transport deposits is rather located at the lower slope and the adjacent basin floor. A so-called infilling drift filled the accommodation space created on the upper slope. The lower drift is characterized by aggrading strata, which turn upwards into seaward prograding clinoforms, similar to those known from the Florida slope. We suggest that the internal reflection configuration of the infilling drift was controlled by intensified ocean currents in the southern GoM during the Cenozoic, in particular the Loop Current and its counter flow. Similarly, the truncation of topset strata in 300 m water depth are attributed to the intensification of the Loop Current. An unconformity up to 25 m below sea-floor can be related to the Mid-Pleistocene transition. We conclude that the transition was accompanied by a time period of significantly enhanced current velocities.

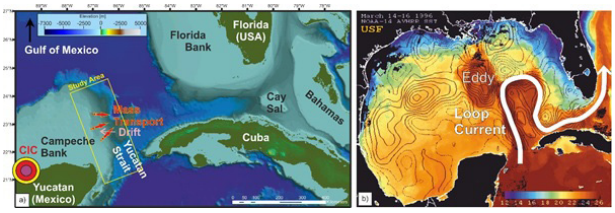

Figure a) Study area in the southern Gulf of Mexico. CIC: Chicxulub impact crater. b) Seasurface temperature and Loop Current (source: NOAA).

Deformation and rheology of the Central Andean lithosphere

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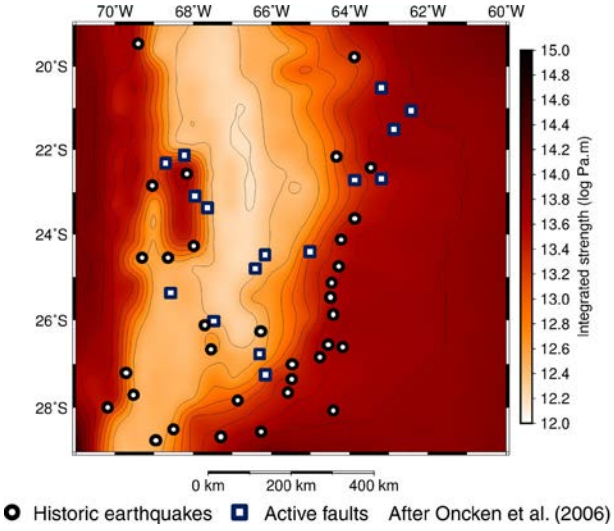
Deformation processes in the Central Andes are complex and heterogeneous. The location and style of deformation in the orogenic front change along strike. North of 22°S, a thin-skinned fold and thrust belt (Subandean Ranges) progressively propagates to the east through a décollement detached in Paleozoic units; whereas south of 22°S, thick-skinned systems (Santa Barbara System, Pampean Ranges) irregularly deform the foreland. Previous studies have investigated the controlling factors on such heterogeneity; however, most of them have focused either on the uppermost crust (i.e. sediments and inherited structures) or the nature of the subduction zone. In this contribution we analyze the link between the observed deformation and the physical state of the lithosphere. We have previously published a 3D data-constrained density model of the region validated through forward modeling of the Bouguer anomaly. Based on this model and published values of thermal conductivity and radiogenic heat production for differ-

ent rock types, we calculated the conductive thermal field for steady-state conditions. Subsequently, using the obtained temperatures and published mechanical properties of rocks, we calculated the maximum differential stress for brittle (Byerlee"s law) and ductile (dislocation creep and dislocation glide) behaviors at each X-Y-Z position.



Finally, we constructed yield strength envelopes (YSE) and maps of integrated strength. Interestingly, our results show a correlation between the observed deformation and the strength of the lithosphere. Most seismic events and active faults are clustered in the transition between domains of weak and strong lithosphere.

Investigation of fractal dimensions of impact-induced cataclasite of the Chicxulub impact crater based on an improved semi-automatic image segmentation workflow using SAGA GIS

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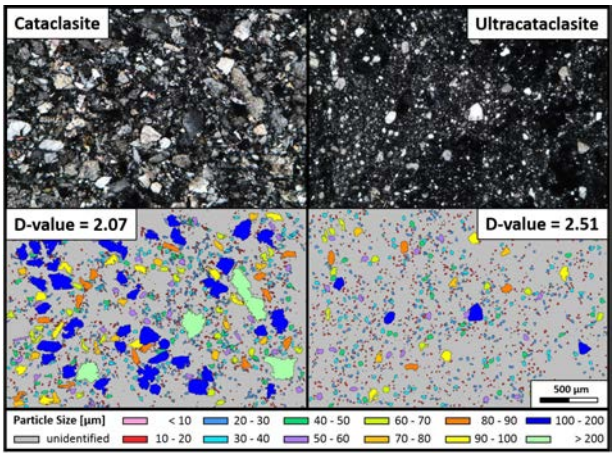
A semi-automatic image segmentation workflow is implemented in the open-source Geographic Information System (GIS) software SAGA GIS (System for Automated Geoscientific Analyses). Specifically, application of an automated seeded-region growing algorithm classifies petrographic thin-section images by polygonization of the grain fabric. Polygonization is based on spectral information of individual mineral phases and is used for assessing particle size distribution (PSD). The workflow was developed originally for petrographic characterization of weathered subarkose sandstone (Asmussen et al., 2015). In our case, the workflow is applied to quantitatively characterize impact-induced cataclasite in granitoid target rock of the 66 Ma Chicxulub impact crater (Mexico). Further to the original application of the workflow to sandstone, cataclasite in peak-ring rocks of the crater is classified based on the amount of matrix in cataclasite and ultracataclasite.

Quantification of the fractal dimension was conducted by calculating D-values of cataclasite in thin section. Analysis of the fractal dimension required the implementation of new tools in SAGA GIS to the regular workflow. These tools include mathematical techniques, notably cluster and principal component analyses, in order to enhance the precision of results. However, usage of the additional tools required higher computing power and, thus, longer processing times. To circumvent these issues, we had to reduce the resolution of the thin-section images in SAGA GIS slightly to ensure avoiding loss of significant image data and, as a consequence, preserving the entire geological information.

The fractal dimension is higher in ultracataclasite than in cataclasite (see figure). However, both cataclasite types show similar sphericity. In contrast to cataclasite, the shape-preferred orientation is well evident in ultracataclasite in almost half of the samples. Results seem to point to a gradient between the two cataclasite types and, thus, a single formation process of cataclasite. In conclusion, integrating tools into the regular workflow of SAGA GIS leads to a more efficient and versatile workflow capable of determining the fractal dimension of rocks characterized by fine-grained matrices, such as cataclasite and volcanic rock.



Future offshore research activities in Northern Chile using RV SONNE

H. Kopp[1], D. Lange[1]

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The northern Chilean margin has been the target site of numerous previous research cruises to the area, including the recent 2016 PICTURES cruise (MGL1610) of RV Langseth. To foster future research activities along the Chilean trench system, we are planning two research

cruises on the German RV SONNE, which have been granted but are not scheduled yet to sail. The PISAGUA cruise will target the 2014 Iquique Mw 8.1 earthquake rupture area using high-resolution controlled-source seismic experiments to elucidate the structural controls on the megathrust slip. Although the 2014 Iquique sequence ruptured a well-known seismic gap where significant strain has accumulated since 1877, the gap only broke partially. The cruise working plan is laid out to complement the results from the PICTURES cruises. We will use 3D and 2D seismic refraction profiling in addition to passive seismology recordings using ocean bottom seismometers. The experiment is located offshore the Integrated Plate Boundary Observatory (IPOC), where rich geophysical datasets during the interseismic, co-seismic and post-seismic phases are available. In conjunction with high-resolution bathymetry mapping, the data will serve a structural comparison of the overriding continental crust and the oceanic subducting slab in the region of the 2014 Iquique event (Pisagua earthquake) between 18.5°S and 22°S.

The second cruise (COMBO: Conjoint monitoring of the ocean bottom offshore Chile) focuses on GeoSEA array deployment sites. In 2015 during RV SONNE cruise 244-GeoSEA, three seafloor geodetic arrays were installed offshore northern Chile on the lower and middle continental plate as well as on the outer rise to record seafloor deformation. High-resolution images of the array sites in conjunction with OBS recordings will yield information on the local subsurface to identify active faults. Ground-truthing using a remotely operated vehicle (ROV) and sampling of active fault zones complement the seismic studies. Knowledge of the structures at depth below the seafloor geodetic transponder stations is still lacking. However, this information is crucial to distinguish between geodetic signals related to the degree of interseismic locking or creep, and the distribution of deformation along the plate boundary and within the overriding plate.

Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the SE coastal region of Brazil

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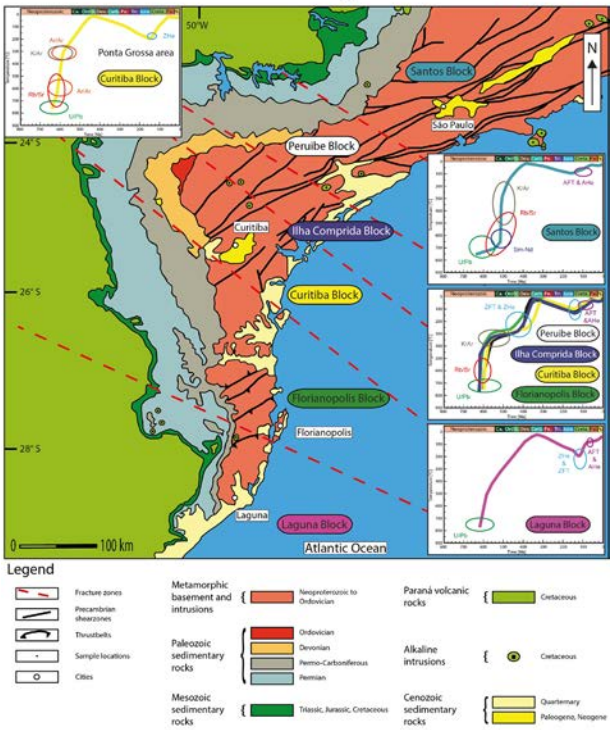
South-eastern Brazil is as an important geological archive for understanding and reconstructing various plate tectonic stages of the Wilson Cycle. In the Neoproterozoic, the area of the today"s South Atlantic passive continental margin (SAPCM: e.g. between São Paulo and Laguna) of south-eastern Brazil underwent subduction, followed by the collision of the contemporary plates of South America and Africa creating a Neoproterozoic orogeny within the supercontinent Gondwana. During the Palaeozoic and Lower Mesozoic (stage 1), the future SAPCM, as an intracratonic area, experienced erosion, denudation of the Neoproterozoic mobile belts (Pan African/ Brasiliano orogeny), and large basin formation (Paraná Basin) (stage 2). Possibly plume-driven pre- to syn-rift (embryonic), ocean spreading (juvenile), and post-break up (mature) processes led to the recent evolution of the SAPCM since the Upper Mesozoic (stage 3).

Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the SE coastal region of Brazil



For the first time, this research aims to reconstruct the syn- to post-orogenic t-T-evolution of Neoproterozoic basement rocks of the SE coastal region of Brazil covering the entire geological evolution since the Late Neoproterozoic. Therefore, this study uses geochronological and thermochronological data combined with numerical modelling. This includes published geochronological data of Neoproterozoic basement samples such as U-Pb, Sm-Nd and Rb-Sr analyses, and low temperature thermochronology (LTT) data revealed by K/Ar, 40Ar/39Ar analyses. To this existing LTT data set, we report new apatite (AFT) and zircon (ZFT) fission-track, and (U-Th-Sm)/ He (AHe, ZHe) data. Numerical modelling of that LTT data attached to the existing geochronological data indicates the following evolution:

- -Stage 1: In the central part of the future SAPCM, the Pan African/Brasiliano post-orogenic cooling and

exhumation (uplift and erosion of Neoproterozoic rocks to the surface) history occurs in three phases: (i) rapid Late Neoproterozoic exhumation, (ii) a period of relative thermal stability (temperatures of about 200-300°C) in which rocks reside at upper crust levels during the Early Cambrian to Devonian, and (iii) a second rapid exhumation phase moving the Neoproterozoic basement rocks to the surface during the Devonian. The northern and southern parts indicate a distinct post-orogenic exhumation suggesting faster cooling and exhumation from the Late Neoproterozoic to Devonian/Carboniferous than in the central section.

- -Stage 2: A phase of subsidence leading to the formation of the Paraná Basin followed by pre- to syn-rift processes and the emplacement of the Paraná-Etendeka flood basalts.
- -Stage 3: Post-South Atlantic break up processes, such as erosion and exhumation.

Paleoclimate, paleoenvironment, and paleoecology of Neogene Central America: Bridging continents and oceans (NICA-BRIDGE)

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In March 2020, we will hold a workshop in Nicaragua to plan scientific drilling in Lakes Nicaragua and Managua. Both are located in a trench-parallel half graben that hosts the volcanic front and that developed during or prior to the Pliocene, as a consequence of subduction-related tectonic changes. The lakes are uniquely suited for multidisciplinary scientific investigation of long, continuous sediment profiles because of their: 1) long records (several Myrs) of terrestrial and related marine basin development at the southern Central American margin, 2) alternating lacustrine and marine environments, 3) proximity to both the older and the younger volcanic arcs, which were separated by slab rollback, 4) significance as a hot spot for endemism, 5) strategic location for study of the great American biotic interchange. They offer the opportunity to combine seismological, volcanological, paleoclimatological, paleoecological, and paleoenvironmental studies in the ocean and on land. The Sandino Basin, offshore Nicaragua, is the oceanic continuation of the depression in which the lakes are located, and a second, seagoing drilling phase of the project will complement the lake drilling, to understand the evolution of the entire complex margin.

Drilling of the Nicaraguan lakes, under the broad umbrella of Paleoclimate, Paleoenvironment, and Paleoecology will have broad scientific and socio-economic impacts andcontribute to three major societal themes addressed by ICDP: Climate & Ecosystems, Deep Biosphere, and Natural Hazards. The workshop will foster international collaborations and serve to further define and refine the scientific objectives and hypotheses outlined in the drilling workshop proposal.Seismic pre-site surveys in the lakes approve the feasibility to drill, and will be continued.

Long, continuous sediment cores from multiple sites in Lakes Managua and Nicaragua will provide the oldest lacustrine records in continental Neotropics. They will enable (a) development of a Neotropical environmental and paleoclimate record, e.g. past moisture availability/source , (b) determination of the times and rates of marine transgressions and regressions, their tectonic and climatic controls and ecological consequences, (c) investigation of recurrence rates and magnitudes of natural hazards, e.g. eruptions, landslides, earthquakes, hurricanes, (d) constraints on the timing and magmatic compositional changes during shifts of the volcanic arc, (e) linkages between longterm terrestrial and marine paleoenvironmental records, (f) long-term basin development, and the deeper structure of western Nicaragua, and (g) assessment of climatic, geologic and (Holocene) anthropogenic influences on biodiversity and limnological variables, e.g. past freshwater/saltwater phases, initiated by tectonics, and consequent effects on micro- and macrobiota.

Structural control on carbon dioxide diffuse degassing at the Caviahue – Copahue Volcanic Complex, Argentina

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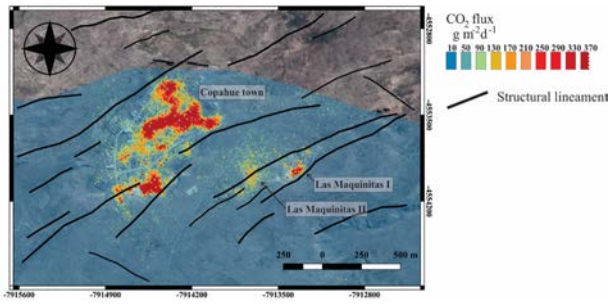
The Caviahue – Copahue Volcanic Complex (CCVC) is located within the Andean Cordillera, in the Neuquén province, Argentina. This magmatic system lies within the northern termination of the Liquiñe – Ofqui fault zone, a 1,200-km-long intra-arc strike-slip fault system. Fluid emissions at this active volcanic complex are fed by a hydrothermal reservoir located at 800 m depth, mostly recharged by meteoric water. The reservoir is heated by a magmatic body located at 5 km depth, which also provides the system with magmatic gases. Fluid emissions

at the CCVC release over 200 tons per day of soil diffuse CO2. The aim of this study is to evaluate the control that the local structural scenario exerts on CO2 flow, from the hydrothermal reservoir to the surface.

The correlation between diffuse degassing anomalies and geological brittle structures was evaluated by performing a spatial analysis with the use of geochemical and structural data. A total amount of 1,819 measurements of CO2 flux and soil temperature were performed, over an area of ~10 km2. CO2 flux data was processed in order to map the spatial distribution of diffuse emissions. The local structure was characterized by means of satellite images and digital elevation models interpretation.

The geochemical analysis showed well-defined CO2 diffuse degassing anomalies in four hydrothermal sites within the CCVC. These anomalies follow clear linear trends that can be clustered in different domains regarding their orientations. The principal domain strikes NE-SW. The analysis of the satellite images and digital elevation models allowed discriminating three sets of structures. The main set is constituted by NE-SW lineaments; the second set is constituted by NW-SE lineaments; the third set is composed by E-W oriented lineaments. Two length-weighted rose diagrams were computed, plotting diffuse degassing anomalies directions and geological brittle structures directions. The similarity of these plots suggests that the main NE-SW structures constitute the preferential pathways for soil diffuse CO2. This also suggests that the two secondary sets act as fluids pathways as well.



Seafloor geodesy to monitor deformation offshore Northern Chile (GeoSEA)

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Within the last decade, satellite-based geodetic techniques such as GPS or InSAR have increased our knowledge about tectonic plate motions and crustal deformation. However, the electromagnetic waves used by these techniques do not penetrate into water and therefore geodetic information for the offshore domain is sparse. The GeoSEA (Geodetic Earthquake Observatory on the SEAfloor) array uses acoustic ranging techniques between stations on the seafloor for relative positioning. We use data from 23 autonomous acoustic transponders installed in three deployments located on the outer rise and on the marine forearc of the northern Chile subduction zone (~21°S). The networks are located immediately south of the Iquique 2014 Mw 8.1 rupture zone. Stations were deployed in December 2015 and were mostly recording until June 2018.

The geodetic networks monitor crustal deformation of the seafloor with the target to quantify interseismic deformation. Although we achieve a mm-scale precision with our acoustic ranging system, we observe no significant deformation above our resolution limits. We compare our observations with surface strain models estimated using onshore cGPS stations of the Plate Boundary Observatory Chile (IPOC). The predicted strains are of a similar order of magnitude compared to the strain resolution of the network. Furthermore, we show pressure data for all three networks. Although the resolution of the pressure sensors is in the cm-range, the data do not reveal any sudden vertical movements of the seafloor, indicating absence of vertical crustal movement.

Exhumation history of the Argentine Eastern Cordillera at 23°S

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The onset of the Andean Orogeny in the Central Andes remains a topic of active research. Many studies investigating surface uplift gave concentrated on the region between 22° - 26° S (see Reiners et al., 2014). They mostly focus on the Cordillera de Domeyko, Coastal Cordillera, the southern Puna - Eastern Cordillera and the Sierras Pampeanas, while very little information is available from the northern Puna to the Eastern Cordillera (Deeken et al., 2005; Haschke et al., 2005; Insel et al., 2012; Reiners et al., 2014).

The Eastern Cordillera at 23°S consists of a narrow zone up to 100 km wide with more pronounced structural relief than the Puna, which lies adjacent to the west. It is characterized by three main mountain ranges and intermontane valleys with a NNE-SSW orientation and is delimited by fore- and back-thrust. These thick-

skinned faults superimpose Precambrian to Ordovician basement rocks onto Mesozoic to Cenozoic sediments. Recent works have studied these major faults, as they represent the record of compressional activity since the Palaeogene (e.g., Coutand et al., 2001; Monaldi et al., 2008; Insel et al., 2012; Montero-López et al., 2018). In order to investigate the temporal and spatial exhumation pattern of this part of the Andes we present fission track and (U-Th-Sm)/He analysis of apatites and zircons from the Aguilar, Mal Paso and Aparzo mountain ranges.

The distribution of cooling ages and similar cooling patterns shown by the AHe, AFT, and ZHe chronometers show a rapid exhumation phase between 18 – 7.5 Ma which we interpret to be caused by the increase of the Andean shortening. Exhumation and deformation were coupled in space and time at the eastern border of the northern Puna and throughout the Eastern Cordillera.

This work was supported by; FONCyT-PICT-1274 and CONICET-DFG: „SuRface processes, TEctonics and Georesources: The Andean foreland basin of Argentina (StRaTEGy)“.

Neotectonics of the Andean Plateau (Puna)

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The northern Puna of Argentina comprises wide areas of the Miocene San Juan del Oro surface, an erosional surface that marks the cessation of deformation on the central Andean plateau. This observation is based on undeformed volcanoclastics at its base, dated to 8.8 to 12.5 Ma. Some studies suggest that the deformation processes migrated from the Altiplano to the Puna and from the magmatic arc in the west to the Eastern Cordillera and subsequently to the foreland of the eastern Andes. Crustal seismicity and GPS measurements indicate the foci of stress release in the fold and thrust belt and the broken foreland, respectively. Our preliminary analysis of faults within the plateau suggests that this notion of tectonic quiescence on the plateau is wrong. Fault scarps with a throw of several meters to tens of meters cut through alluvial sediments that were probably deposited within the Quaternary; lacustrine terraces of formerly extensive lakes are deformed asymmetrically, and fluvial terraces and alluvial fans are tilted. Since the recent deformation of the plateau margin is proposed to be highly influenced by inherited crustal structures, e.g. reactivated ancient fault systems, gaining a better knowledge of past deformation features and a rigorous analysis of recent faults is critical for understanding the present and possible future state of deformation. In this context it is surprising that younger fault systems have not been analyzed in this region, which, however, is partly the result of existing models that no active deformation occurs in the central sectors of the plateau.

Our aim is to study these younger fault systems with respect to their latest tectonic activity. Therefore, we collected a dozen samples for U/Pb dating of volcanic ashes and quarzitic gravel samples for cosmogenic radionuclide dating. Age constraints of the tectonically-imprinted geomorphic features will provide valuable data to enlighten the past seismogenic deformation. Additional research on these structures will include interpretation of seismic refraction lines, analysis of historical aerial imagery, UAV-based mapping of morphological indicators and fault trenching. The combination of these techniques will help us to achieve our principal goal to characterize the neotectonics behavior of the Puna Plateau region. As such the results will help to decide, where shortening across the Andean orogen is accommodated and how the tectonic activity has evolved over time, which is critical for the development of models of orogenic wedge behavior and therefore, for understanding the growth of mountain belts. Furthermore, the outcome of this study will be inevitable for the assessment of natural geologic and geophysical hazards in the plateau region.

Geodynamic importance of the spatial distribution of monogenetic volcanic centers in the Southern Andes between 39°S and 37°S

Y. Lee[1], P. L. Göllner[1], U. Riller[1]

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The interplay between tectonics and volcanism is one of the major, and in many aspects, unresolved chicken-and-egg questions at active continental margins. Specifically, the influence of upper crustal deformation structures on the development and location of volcanic centers remains to be identified in many volcanic arcs. Along the Southern Andean volcanic zone, individual stratovolcanoes often form volcanic lineaments, many of which coincide with the presence of major crustal discontinuities. In contrast to prominent volcanoes, small eruptive centers, polygenetic fields and monogenetic cones are however mostly underrepresented in volcano-tectonic studies. As the activity of such eruptive centers is in many cases limited to a small time window, they lend themselves well with regard to correlating individual pulses of deformation with pulses of volcanism. Thus, they are ideal targets to study the influence of deformation on magma eruption.

Widespread Cenozoic volcanic activity in the Southern Andean volcanic zone between 37°S and 39°S lead to the formation of a variety of volcanic centers, such as collapse calderas, stratovolcanoes, and abundant monogenetic cones. A systematic and comprehensive analysis of the spatial arrangement of especially small eruptive centers with respect to regional structures is however lacking. In this study, we compiled the type and location of

volcanic centers in the Southern Andean volcanic zone. We present preliminary results of a comprehensive GIS-based analysis of the alignment of volcanic centers and their correlation with upper crustal structures. Volcanic centers used for this purpose were compiled from published sources and satellite imagery in combination with topographic maps. Our systematic assessment shows a number of linear spatial assemblages of mostly monogenetic cones of basaltic composition trending NE-SW in the Loncopué trough, a pronounced topographic depression of the back arc. NE-SW-trending volcanic lineaments are at variance to the strike of prominent faults observed in the study area, but correspond to the principle shortening direction in the Southern Andes imposed by oblique plate convergence. This observation suggests that monogenetic volcanic centers, which are generally thought to have been fed from the mantle, formed by local NW-SE dilation of faulted crust under overall NE-SW compression. Consequently, maximum principal compression during basaltic volcanism in the Loncopué trough was horizontal rather than vertical, as is commonly believed. This calls into question the popular back-arc extension hypothesis for the Southern Andean volcanic zone.

3D seismic tomography and seismotectonics of the Ecuadorian margin inferred from the 2016 Mw 7.8 Pedernales aftershock sequence

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Based on seismicity recorded by the permanent Ecuadorian seismic network and our large emergency array installed shortly after the 2016 Mw 7.8 Pedernales earthquake, we derived a 3D velocity model of central coastal Ecuador using a local earthquake tomography. We manually analysed the seismic waveform recorded on the amphibious array to determine high quality P- and S-wave arrival times. Joined inversions for earthquake locations, velocity structure and, if applicable, station correction terms were carried out with increasing complexity from 1D to 3D.

From the tomography we imaged the subducting oceanic Nazca plate down to 50 km depth inferred by a high Vp feature dipping eastward. The distribution of the relocated seismicity is mostly distributed along the plate interface and allow us to identify the boundaries between the subducting and overriding plate. Changes consistent with the north-south transition from an accretionary to erosive regime were found. To the north, in the marine forearc section we image areas with high Vp/Vs contrast where seismicity close to the trench is located. This finding might suggest the presence of eroded or fractured wedge capable to trigger seismicity after a large megathrust earthquake. Also, we observe a low Vp region which might co-locate to areas where slow slip events have been identified. The southern section shows a wider zone of seismicity suggesting a thicker crust subducting beneath the continental plate that can be associated with the influence of the incoming Carnegie Ridge. The presence of this large bathymetric feature also adds buoyancy to the incoming oceanic crust and might affect the way how stress is released in this area. In the overlying continental crust, we observed clustered shallow seismicity in both northern and southern profiles which is located at the limits of high Vp/Vs bodies. Moreover, our results show how the Bahia Caraquez and Manta cluster, both registered after the Pedernales earthquake, surround a body that might correspond to a less consolidated area in the marine forearc. Finally, we can co-locate a high Vp/Vs body located in the east part of the southern section to areas that recorded high PGA during the Pedernales earthquake. Our results presented here highlight the heterogeneities of the subduction zone that might influence different stress release behavior over time and can coexist and interact even in a local to regional scale along the central coastal Ecuadorian margin.

Miocene volcaniclastic foreland basin infill next to the exhumed North Patagonian Andean Batholith: a record of collapse-caldera eruptions?

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The nature of Andean magmatism and their tectonic regimes results from variations in the angle of subduction of the Nazca and Antartic oceanic plates beneath South American plate. For the North Patagonian Andes, a flat slab type subduction was proposed to the middle Miocene. At one time, foreland basins were filled with tens of volcaniclastic materials that were distributed for more than 30.000 km2. In order to understand the relationship between tectonics and magmatic–volcanic system interactions, we analysis the Miocene volcaniclastic infill succession of a basin located next to the exhumed Andean Batholith.

The Collón Cura basin was configured between 16 and 14.4 Ma due to the uplift of the north Patagonian Andes towards the west and the Sañicó Massif towards the east, whereas the uplift of the North Patagonian Andes continues up to 4.8Ma. At the same time, a volcaniclastic succession of tuffs and lapilli tuffs were deposited into the basin with up to 150 m-thick that reach an estimated volume of ~1800 km3. The succession is limited below by an angular unconformity and above by a regional erosional unconformity and is characterized by three sections. The lower and upper sections are composed of ~50 - 70 m-thick of massive to roughly stratified and moderate-sorted vitric-rich lapilli tuffs. The middle section is characterized by 10 to 30 m thick of lenticular beds composed of massive, vitric-rich and moderately sorted lapilli-tuffs. Geochronological and magnetostratigraphic analysis constrain the volcaniclastic succession between 15.160 and 12.049 Ma and reveals that the whole succession has a normal polarity paleopole dated between 15.160 and 15.032 Ma, determining a maximum depositional time process of 128.000 years. Nevertheless, sedimentological features of the succession indicate that deposits were probably deposited even in a much shorter time span.

The deposition of the volcaniclastic succession was interpreted as short-term processes associated with PDC´s occurred during the main structural configuration of the basin that matches with the contractional flat slab regime. The volcaniclastic succession of the Collón Cura basin would record a huge volcanic eruption deposited by catastrophic events in a many or nested collapse-caldera scenario. The origin of the calderas would be genetically associated with Miocene igneous rocks of the North Patagonian Batholith, that was exhumed in the North Patagonian Andean axis after the flat slab regime.

Seismic processing strategy and crustal structure of the April 1, 2014 Mw 8.2 rupture area offshore Northern Chile from seismic reflection data

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The northern Chilean margin has long been recognized as an erosive margin, which has been active since the Jurassic. Along the Chilean trench system, material transfer changes from accretionary south of the Juan Fernandez Ridge (~33°S) to erosive in the north offshore Antofagasta (~23°S) and Iquique (~22°S). Because of its rich earthquake history and the systematic spatial variation in geologic factors that potentially affect megathrust rupture, the Chile subduction zone is arguably one of the best places on Earth to understand the effect of crustal structure and megathrust geometry on the behavior of continent-ocean subduction plate boundaries. On April 1, 2014, a magnitude Mw 8.2 earthquake ruptured the marine forearc offshore Iquique and Pisagua between 18.5°S to 21°S, covering an area spanning about 20% of the region previously referred to as a seismic gap. This event did not compensate the entire slip deficit and hence the continuous potential for a large rupture makes a close investigation of the fault slip zone timely.

In 2016 RV Marcus G. Langseth set out to acquire deep-penetrating, high-resolution seismic data in the 2014 rupture area during cruise MGL1610 under the framework of the PICTURES (Pisagua-Iquique Crustal Tomography to Understand the Earthquake Source) project. A grid of seismic reflection and refraction profiles were acquired to document the geologic structure of the upper and lower plates and the rheological properties of the boundary zone between them. Here we present first results from processing of line MC25, which is located in the southern part of the 2014 rupture area. Due to the starved sediment and strong signal, the seafloor multiple is quite strong in the shallow part. The shot interval of the raw data is 125 m, which leads to prominent aliasing in the original gather. To dismiss these aliased data, shot interpolation is applied in the raw data, leading the shot interval from 125m to 15.625m. As the result is not a multiple for the receiver interval, an irregular interpolator module was used to interpolate it to 12.5 m. After that, the shot gathers have no aliased components associated with them and meet the standard coordinate system. Several processing techniques are introduced with the aim to increase the signal/noise ratio. Focusing on the multiples, we utilize enhanced multiple suppression techniques, e.g., wave equation multiple attenuator, deterministic water-layer demultiple, interbed multiple predictor, anomalous amplitude noise attenuation, adaptive filter and multichannel dip filter to improve the imaging quality at greater depth.

Crustal deformation and loading effects in southern Patagonia

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GNSS observations well distributed over the Southern Patagonian Icefield (SPI) region have revealed rapid uplift with rates of up to 4 cm/a (Richter et al. 2016; Dietrich et al. 2010). The magnitudes and patterns of vertical and

horizontal present-day crustal deformation reflect the contribution of three major processes: glacial-isostatic adjustment (GIA), plate tectonics and the opening of the Patagonian slab window. Furthermore, the observed site displacements are affected by the elastic response of the solid earth to short-term load signals, e.g. hydrological loading, ocean tidal loading and atmospheric loading.

Current regional models of GIA (Lange et al. 2014; Ivins & James 2004) explain the observed uplift essentially as a superposition of the visco-elastic response to ice-mass changes since the Little Ice Age and the elastic response to ongoing fast ice retreat. Glacial-isostatic relaxation is unusually fast in Patagonia due to the peculiar tectonic-rheological setting characterized by the subduction of an active oceanic ridge at the Chile Triple Junction, the opening of the Patagonian slab window and the upwelling of low-viscosity mantle material underneath the ice-fields.

Progress in our understanding of GIA in Patagonia depends on the ability to separate the visco-elastic and elastic contributions to the observed uplift. A quantitative modelling of the elastic response to ongoing surface mass changes requires two input models: an elastic earth model and a load model which describes the spatial mass distribution of the load. GRACE satellite gravimetry data have been recently used to estimate ice mass changes of the Southern and Northern Patagonian Icefields over 15 years (Richter et al. 2019). These results serve as a basis for an improved load model for the calculation of elastic glacial loading effects.

Here we present modelling results of the elastic response to present-day ice mass changes in southern Patagonia. In addition, we show elastic loading effects derived for selected hydrological loading scenarios in the region under investigation, including the impacts of the Perito Moreno glacier dam rupture and the planned Rio Santa Cruz dams. These results are evaluated with regard to the contribution of hydrological loading on the geodetic observables and their potential for validating or constraining the elastic earth model.

The nature of the North-South change of the magnitude of tectonic shortening in Central Andes at Altiplano-Puna latitudes: a thermomechanical modeling approach.

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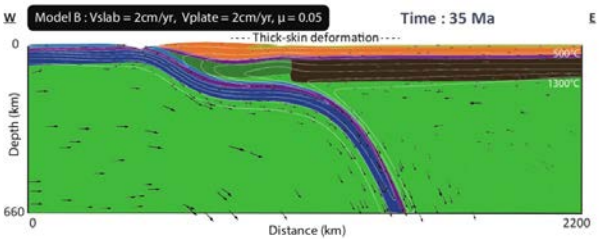
While an orogeny typically involves the collision of 2 continental plates, the Andean orogeny formed in a context of subduction, with the oceanic Nazca Plate sinking under the continental South American Plate. Whereas the subduction has been active since ~180 Ma, the shortening of the Andes initiated at ~50 Ma. Moreover, the ~300 km shortening in the Central Andes in Altiplano at about~19-21°S contrasts with less than 100 km shortening at ~15°S and ~25°S. This raises the question of the cause of change of the shortening magnitude. We hypothesize that the difference in the strength of the upper plate causes differences in tectonic styles resulting in variable rates of trench roll-back. The parameters that weakened the continental plate and controlled the tectonic style of the foreland deformation (thin-skin, thick-skin) were investigated previously, without regarding the subduction. This project aims to build on previous work by using the Advanced Solver for Problems in Earth"s ConvecTion (ASPECT) to numerically simulate 2D and 3D visco-plastic models of the interaction of the subducting Nazca plate and overriding South America plate. First, we will run high-resolution 2D East-West cross sections along the Altiplano and Puna latitudes. Second, we plan to extend the previous cross-sections to a 3D model of the entire region. Finally, we will update the 3D model of the lithospheric structure in the Puna region developed by our partner project. This project is supported by the International Research Training Group StRATEGy.



Evidences of permafrost degradation in the arid Andes and its potential effect on hydrological resources

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Buried ice forming different ice-bearing permafrost deposits in arid mountains has been recognised for a long time as an important water resource. However, the complex interactions between precipitation, temperature, ground heat transfer and water phase changes within the ground is not well understood. Disconcertingly, the two main variables for the existence of ice-rich permafrost deposits are in jeopardy: temperature is rising in concert with the global warming tendency and regional studies in the arid Andes indicate that precipitation dropped by half in the last century (Vuille and Milana, 2007). Therefore, this long-term climate tendency leaves no doubts that ground-ice is suffering degradation, endorsed by three studies: 1) detection of taliks at the permafrost of the Agua Negra pass (Schrott, 1996), 2)

incomplete refreezing of the active layer during winter near the same location (Croce and Milana, 2002), and 3) indirect evidence of permafrost degradation from the common occurrence of permafrost-derived molards in landslides amounting for ca. 30% of the reported molards worldwide (Milana, 2016). Non-published examples found in the arid Andes in Chile would rise that number to 50% suggesting that landslides related to permafrost degradation are abnormally high in the arid Andes, as expected from the combined effect of temperature rise and precipitation decrease. The recent effort of Argentina and Chile to map their glaciers and other cryospheric bodies, both due to new laws and a social pressure on governments, helps to understand the potential effect of losing part of the ground ice in the arid Andes. Preliminary cryospheric inventory mapping indicates that for large regions as the Atacama (Chile) with semiarid, arid and hyperarid environments, the surface coverage of buried ice is 95.3% of all ice-bodies while glaciers only account for 4.7%. Preliminary models of water production however suggest that these 95.3% (without considering seasonal snowmelt) may account for only 63% of the total water supply (glaciers: 37%; García et al., 2015). The more serious problem of the buried ice is that, while exposed ice tends to occur at high altitudes, well above the 0ºC mean annual temperature (MAAT), mapped buried ice frequency peaks quite close to the position of the MAAT, suggesting that just a minor increase of ambient temperature will leave "unprotected" larger areas of ice-bearing permafrost fostering its degradation and creating a significant impact on future water reserves. This ice-buried resource, although considered "permanent", is actually activated during the periodic droughts in years almost without seasonal snow.

Deciphering a steep erosional gradient in the hyperarid core of the Atacama Desert, northern Chile

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The impact of endogenic and exogenic factors on the formation of topography is difficult to assess, mainly because (1) the processes shaping the topography mostly integrate over long time scales and (2) due to the spatial heterogeneity of large-scale study areas, i.e. with respect to synoptic conditions or lithology, amongst others. Thus, to enhance our understanding on how Earth-shaping processes are linked and how they affect the formation of topography, it is desirable that as many endogenic and/or exogenic factors as possible can be considered to approach uniformity and/or to be constant on the long-term perspective.

The hyperarid core of the Atacama Desert in northern Chile is well known for its long-term climatic stability (i.e. long-term hyperaridity), limiting the formation and maintenance of drainage systems in this area. However, the uplift of the Coastal Cordillera introduced potential energy promoting fluvial incision, which has led to the formation of numerous, isolated small-scale drainage systems in this area. On the northern rim of the E-W oriented Río Loa canyon (latitude 21.4°S), such incision took place into an alluvial surface of at least Miocene age. The uniform substrate and long-term stability of synoptic conditions favor the study of the impact of local (micro-) climate and climate change, erosion, atmospheric deposition and local tectonics on the formation of topography in this area. For our multi-temporal analysis, we measured concentrations of terrestrial cosmogenic nuclides (TCN; 10Be, 26Al and 14C) from channel pebbles and inferred time-integrated catchment-averaged erosion rates of catchments located within a short (2.5 km) E-W transect, i.e. parallel to the Río Loa canyon. We combine TCN data with an analysis of catchment-averaged geomorphic metrics and an unmanned aerial vehicle (UAV)-based mapping of the distribution of gypsum crust cover. In summary, we find that erosion rates increase by one order of magnitude from East to West. A topographically modest tectonic ridge separates a detachment-limited erosional regime in the west from a transport-limited regime to its east. The ridge"s crest also marks the western boundary of significant gypsum surface crust cover. However, the present-day gypcrete distribution indicates a polyphase (at least two-phase) incision of the drainage networks. The differential evolution of drainage in our study area might have commenced near to the Pliocene/Pleistocene boundary.

Early evolution of the Gulf of Mexico: Synrift successions, climate, and tectonic setting

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The Gulf of Mexico is a subsidiary basin to the Atlantic, resulting from Jurassic break-up of Pangea. The rotational hypothesis for its origin is now widely accepted, and it is supported by satellite-derived gravity, paleomagnetic, and aeromagnetic data. Other issues are far less understood, such as a full closure fit, the rifting process and stratigraphy, and the driving mechanism. More importantly, the paleogeographic evolution has important implications for hydrocarbon exploration. The Mesozoic stratigraphy of Mexico recognizes a Late Triassic rifting episode in the El Alamar Formation and the Todos Santos Formation sensu Valle Nacional. This episode may correspond to a wide rift mode, and it is required to bring Yucatan from its pre-drift position to a position consis-

tent with Late Jurassic counterclockwise rotation. New field and provenance data for the Todos Santos Formation recognized an Upper Triassic fluvial siliclastic succession in the western Veracruz basin. Here, Todos Santos is intruded by a ~194 Ma pluton (U-Pb). The early-rift Triassic succession was halted during a long episode (~196-165 Ma) of continental arc magmatism, and did not lead to sea floor spreading. A key to understanding driving mechanisms to open the Gulf is provided by the dynamics of the Nazas trench, which records an evolution from an Early-Middle Jurassic extensional arc to mature rift basins.

Records of Jurassic continental arc volcanism in east and southern Mexico include La Boca Formation, in the Sierra Madre Oriental, and La Silla Formation north of the Chiapas massif. These units are correlated with the Nazas Formation (Nazas arc) of central Mexico, and the units pertaining to the Jurassic Cordilleran arc of Sonora, as well as the Jurassic arc of the Central Cordillera of Colombia. The main rift succession associated with opening of the Gulf of Mexico is younger than about 170 Ma, based on young zircon ages at multiple locations. In Chiapas, synrift deposits correspond to the Todos Santos Formation sensu Concordia; here, coarse-grained, pebbly, arkosic sandstones with thin siltstone intercalations and thick conglomerate packages are interpreted as deposits of a high-gradient, axial rift, fluvial system fed by transverse alluvial fans derived from the rift shoulder. Sr-isotopes from the Louann and Campeche subsurface evaporites date earlier marine incursions into the Gulf to about 167-169 Ma. The Bathonian-Callovian incursions were followed by a basin-wide Late Jurassic transgression that accompanied sea-floor spreading.

As Pangea ruptured, Jurassic northward migration of Mexico, which lay on the southern part of the North America plate, resulted in temporal evolution of climate-sensitive depositional environments. Prior to opening of the Gulf, Lower-Middle Jurassic rocks in central Mexico contain a record of warm-humid conditions; these are indicated by coal, plant fossils and compositionally mature sandstone. Paleomagnetic data for central Oaxaca and other regions of central and eastern Mexico indicate that these rocks were deposited at near-equatorial paleolatitudes. In the Late Jurassic, as the Gulf of Mexico formed, eolianites and widespread evaporite deposits indicate dry-arid conditions. Available paleomagnetic data (compaction-corrected) for Upper Jurassic strata in central Mexico indicate deposition at ~15-20ºN.

As North America moved northward during Jurassic opening of the Atlantic and the Gulf, different latitudinal regions of the continent experienced coeval Middle-Late Jurassic climatic shifts that have been widely recognized in the Colorado Plateau in the United States. Affected by the same northward drift as the plateau, the southern end of the North America plate represented by central Mexico gradually reached the arid horse latitudes in the late Middle Jurassic as the Colorado Plateau was leaving them. As a result, Late Jurassic epeiric platforms surrounded by arid landmasses developed in the circum-Gulf region. We propose that hydrocarbon source-rock deposition was facilitated by arid conditions, fertilization by continental silt, and wind-induced coastal upwelling.

Regional depocenter geometry and subsurface frontal structural features in the foothills and western foreland llanos Sub-Andean basin (Colombia) based on gravimetric modeling

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Regional scale studies play a key role in understanding the tectonic evolution of sedimentary basins. As part of them, gravimetric modeling constitutes an important tool to improve geological knowledge, especially in areas with limited accessibility or frontier basins. Using recently reprocessed airborne gravity data, 3D tomographic PSDM velocity field as well as density well data, an integrated density model was built. Regional to sub-regional changes in depocenters and subsurface frontal structural features from the foothills and western foreland llanos Sub-Andean basin (Colombia) were mapped and modeled.

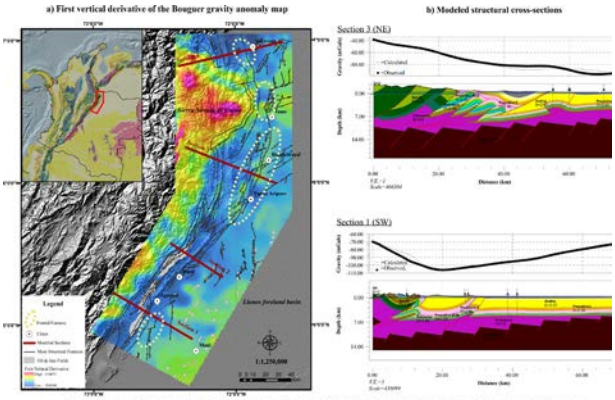

Fig. 1 a) Study area. Modeled cross-section locations in red, and inferred frontal structural anticlines (enhanced positive anomaly changes) in pale yellow ovals
b) Interpreted cross-sections 1 (SW) and 3 (NE), modeled against observed and calculated gravity

The basal configuration of the northern part of the study area shows a deeper basement allowing more accommodation space for the younger sedimentary sequence than the central and southern areas. Clear gravimetric positive anomalies, topographic and reflection seismic data, suggest the existence of deeper frontal structural features, relevant as hydrocarbon-bearing traps and possible prospective CO2 storage areas. Higher density rock units (slightly metamorphized-Paleozoic sequence or crystalline-Precambrian basement) are inferred to be included within the observed Pop-Up structures, which formed as a result of Mesozoic normal fault inversion during the Andean orogeny. These features are also re-

flecting a tectonic style change along a SW-NE trend, with a transpressive component setting in at 5.7° N that is consistent with a regional convergent and oblique tectonic setting. Presence, sizes, vertical displacements and gravimetric anomalies of these structures are possibly a function of the proximity to Sierra Nevada del Cocuy due to the amount of compressive stress.

Dam Collapse: the case of Brumadinho – 2019 (Brumadinho, Minas Gerais – Brazil)

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Brazil is known for its mining strong economic activity. In the 18th Century, the intense mineral extraction resulted in the construction of roads from the country to the coast, in order to transport the production. Many small towns were formed around these new sources of jobs and services, such as Brumadinho. There are many mining areas with full infrastructure around this town. In the midst of these activities, on January 25th, 2019, the Corrego do Feijao tailings dam collapse occurred, leaving 238 people dead.

Three years ago, there was the worst environmental disaster in Mariana, Minas Gerais State, when the Mina do Fundão tailings dam collapsed, in November 2015, releasing 62 million cubic meters of mud.

The Corrego do Feijao tailings dam 1 was created in 1976 to contain fine tailings resulting from the mining treatment installation, reusing the water in the industrial process. 40% of solid composite rejects and 60% water are directed to the tailings dam. The tailings dam in a shape of slope is a technology developed by the soil mechanic engineering a long time ago, as a cheaper alternative dam, constructed with soil. The problem is the presence of water. If it is not eliminated, it can be lead to a liquefaction.

Today, the processed iron ore results in a concentrate of about 50%; leaving about 50% of tailings. In Minas Gerais, the production is 350 million tons/year.

The scientific community and the Universidade Federal de Minas Gerais have been debating about this theme of tailings dam disasters in lectures, workshops, and various meetings. These events include actions in order to enable a better understanding about the disaster, resulting in thoughts about preventive measures.

The absence of consistent studies related to continuous surveying and inspection of these dams significantly contribute to a repeated scenario of tailings dam collapses. In addition, the evaluation of scientific and technological resources available but not used is also important for the proposal of public policies.

The general goal is to establish a process that is committed to life and rights of the population harmed, which will demand a long-term intense work to point problems and propose actions on various issues. Issues related to the environment, housing, the creation of jobs and earnings, health, education, culture and leisure, and many other issues that will demand time to create, ponder, and rebuild.

Fig.1- Before and after disaster

Geologic recognition of the Eocene Los Corros fossiliferous level (Esmeraldas formation, middle Magdalena valley, Colombia)

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The Middle Magdalena Valley is one of the most prolific basins in Colombia in terms of historic production of hydrocarbons. The Cenozoic segment in the basin is represented by units that bear the main reservoir rocks, therefore the importance of defining its stratigraphic context.

In the past, at least three fossiliferous levels, consisting of mollusks, have been recognized in this area and all of them have been used as correlation events or elements to define stratigraphic boundaries. In a lesser degree, these levels have been also used to define paleoenvironments. Nowadays, none of the outcropping fossiliferous levels have a detailed sedimentological and paleontological characterization.

In order to deepen on these topics, the type locality of one of the most reported fossiliferous horizons was revisited. A taphonomic survey of the Eocene Los Corros level (upper section of Esmeraldas Formation) illustrates that far from corresponding a discrete interval, with well-defined thickness, it actually comprises a heterogeneous lithostratigraphic segment, where the abundance, preservation, and distribution of the identified mollusks (bivalves and gastropods), suggest a high complexity in the sedimentation environment. For this reason, our results strengthen the idea that a detailed sedimentological and paleontological study of this horizon, would improve the knowledge about the paleoecology of the Esmeraldas Formation.

Presence of critical metals (Sc and REE) in laterites from ophiolitic Moa-Baracoa complex, Cuba. An investiment opportunity for EU?

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Current scientific literature reports the presence of scandium in lateritic deposits in Australia, the Philippines, New Zealand and other countries. According to U.S. Geological Survey (2018) identified resources of scandium are reported in Australia, Canada, China, Kazakhstan, Madagascar, Norway, the Philippines, Russia, Ukraine and the United States of America. Due to its low concentration, scandium is produced almost exclusively as a by-product of the processing of various minerals or previously recovered from industrial tailings and waste. In China, it is obtained as a byproduct of the production of titanium and rare earths; in Russia, from apatite and in Kazakhstan and Ukraine, from uranium. The main uses of scandium are related to aluminum-scandium alloys and manufacture of solid oxide fuel cells (SOFCs). Other important uses are reported in ceramics, electronics, lasers, lighting and radioactive isotopes.

In Cuba, in recent years, the existence of scandium has been established in lateritic nickel and cobalt ores in the Moa region, using ICP-MS analysis. In this work an analysis of the geological and economic meaning of the contents of scandium and REE reported in the ores of Camarioca East, Yagrumaje North and Yagrumaje South deposits and others of this region is carried out. The distribution of scandium mineralization in the lateritic profile predominates in the limonitic horizon, where goethite, gibbsite and hematite appear. It is concluded that the values of the Sc average contents reported show economic potential for the development of geological exploration projects that consider the extraction of scandium and REE as a byproduct of nickel and cobalt production in the Moa region, using the high-pressure acid leaching technology (HPAL).

Basin evolution, lake establishment and orbital scale climatic variability: the ca. 500 ka sedimentary record of Lake Chalco, central Mexico.

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The MexiDrill ICDP coring project recovered a ca. 520 m long sedimentary sequence in the depocentre of Lake Chalco in central Mexico, which constitutes a unique continuous lacustrine sequence that contain the history of origin, geological evolution and paleoenvironmental and paleoclimatic fluctuations during the last ca. 500 ka. The lower 100 m are composed by lava flows and intercalated pyroclastic materials. Seven units were recognized. The lavas are basaltic to basaltic andesitc and the Harker diagrams point to fractionated crystallization and partial fusion as main processes. The ratio 143Nd/144Nd indicate a mantle depleted source; however, the 86Sr/87Sr, 207Pb/ 204Pb y 206Pb/204Pb ratios suggest a cortical component. The age of the lavas remains unknown, but it is considered an age of ca. 500 ka.

On top of the lava flows, depth alluvial fan, debris flow and hyperconcentrated flow deposits were accumulated. At depths 296-280 m, a transition from alluvial to fluvial environment is characterized by turbulent flow deposits associated to a deltaic-fluvial setting, alternating with floodplains laminar flow deposits. The first lacustrine sedimentation occurs at 277 m depth, in a transition between fluvial and lacustrine environment that represents a former body of water named „Paleo-Chalco I". Above 267 m depth the definitive establishment of the lake, „Paleo-Chalco II", is recognized. This is characterized by eutrophic and deep waters. Its origin is probably associated to tectonism and volcanism, as it is preceded by debris flow deposits and a 85 cm thick white pumice deposit. The age of the „Paleo-Chalco I" is ca. 475 ka.

Lacustrine sediments are interbedded with numerous volcanic deposits and show a complex stratigraphy, in which deposits of diatom oozes, ostracod hashes, carbonate facies, and massive to laminated structures occur. The record of past climatic and environmental conditions of the lacustrine sedimentary sequence is currently under investigation, by using a multiproxy approach that includes –among others- elemental geochemistry, diatom, charcoal and pollen analysis and rock magnetism parameters. Current and published work on the upper 120 m, which span the last ca. 150 ka, reveal orbital scale variability recorded in the Lake Chalco sediments. Drier conditions, lower lake stands and higher frequency of fire events are recorded during spring and summer insolation. At the end of the Marine Isotopic Stage 6 (MIS

6), Chalco was a relatively deep and stratified freshwater lake. During MIS 5 fluctuated between low lake levels and marsh and littoral settings with dry periods. Low lake levels persisted during the MIS 4 and MIS 3. The last Glacial Maximum (24.5-19.5 ka) was characterized by low lake levels, and an increase in precipitation during the deglacial. The early Holocene is marked by a sharp change to dry environments, that shift towards more humid after ca. 6.5 ka.

Water chemistry in Somún Cura region, Rio Negro and Chubut Provinces, Argentina.

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The Somún Curá Magmatic Province it is conformed by volcanic and subvolcanic rocks and extends for 25.000 km2 at South centre of Río Negro Province and North centre of Chubut Province in Argentine Patagonia. The entire region under study belongs to a desert regime under extreme temperatures, -25°C in wintertime to 45°C in Summer time, with averages between 3°C to 35°C with very dry conditions. The rainy season is springtime with 50 mm to 225 mm/year. The evaporation/transpiration is higher than rains during all the year. Isotopically the water can be divided in four different groups, one for the north, one for the south with an Atlantic origin of precipitations and two small groups with a local signature (Parica et al. 2012; Parica et al. 2017; Remesal et al. 2017).

If the rains are present in the system the main source of water are located in the high regions (Alta Sierra de Somún Curá, Apas, Talagapa, Sierra Negra de Telsen, etc) after snow melting, water transit occurs through the structures in the Plateau rocks forming. Some salinization may occur during this transit and increasing of temperatures too from upper to lower levels. Surface water is driven through streams, the most important are Valcheta (Rio Negro Province) and Telsen (Chubut Province). Into the basaltic plateau water circulation has place through the structures, from the upper levels by snow melting to lower levels, where the water get salts and temperatures (23° C for southern water outlets and 45°C for northern water outlets).

Water chemistry have a narrow spread, the chemistry of water let to classify them into Calcium Chloride, Calcium Sulphate and Calcium Bicarbonate, with light salinization index, weak mineralization. No As was detected at the localities sampled, with pH between 7.4 to 8.4 these are mainly drinkable waters considering chemistry features and low salinization risks in soils (SAR index).

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The present is the key to the past: an actualistic study on the foraminiferal assemblages of Albuquerque Cay (Colombian Caribbean)

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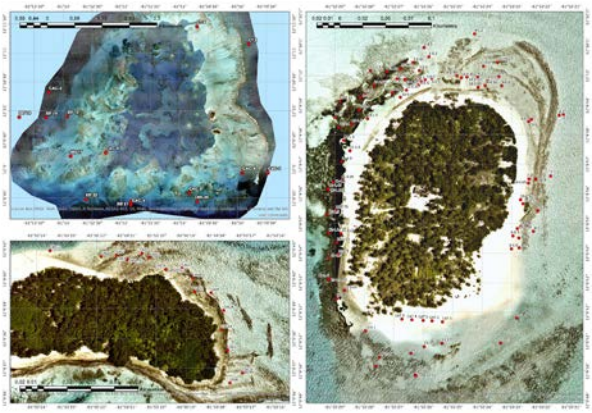
In the Colombian Caribbean, the sedimentary successions and their associated fossils present similarities with their equivalents in the recent marine settings. For instance, the Miocene carbonate platforms of the Sinú-San Jacinto fold belt resemble the recent carbonate platforms, including remotes areas such as the San Andres Archipelago (Western Colombian Caribbean).



Our research tested such similarity on the benthic foraminiferal assemblages. A detailed sampling on recent sediments was effectuated in one of the insular bodies of the San Andres Archipelago. Due its isolated location on the archipelago and tentatively its low stress by human activities, Albuquerque Cay is an excellent place to make those actualistic analysis. On the other hand, sub-recent (hardground levels) and middle Miocene samples were collected in both the same cay and the neighboring San Andres Island.

As expected, the foraminiferal assemblages in Albuquerque are abundant and diverse, where the symbiont-

bearing genera (Archais, Amphistegina among others), the porcelanaceous and hyaline forms are dominant. Moreover, the proportion and distribution of some of the identified forms might be controlled by physico-chemical factors such as the light incidence and the associated substrata. On the other hand, the hardgrounds and the middle Miocene samples presented similar foraminiferal assemblages, though in a lower preservation due transport and moderated dissolution processes. Notwithstanding, the middle Miocene samples of San Andres are enough resolutive to corroborate previous paleoenvironmental interpretations in the island. Therefore, future paleoenvironmental studies in the Cenozoic of the San Andres Archipelago and the Colombian Caribbean could be favored with detailed foraminiferal studies in the recent settings.

Advances in B isotope analysis of silicate rocks – applications in arc settings (Chile)

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The composition of Earth"s crust is modified from primitive mantle by processes such as fractionation and fluid mobilisation, which can be traced by fluid mobile elements and stable isotopes. Boron is a particularly useful indicator for fluid mobility and low-temperature fractionation. Kineticly controlled fractionation of 11B and 10B can be related to fractional crystalisation or the growth of secondary minerals. However, the analysis of B isotopes in samples with low concentrations (<3 ppm) of B is technically challenging, owing to the high volatility of B during chemical processing and usually high B blanks even in class 100 labs. We present a re-evaluation of B separation protocols, involving the widely used high temeprature, K2CO3 flux fusions and the low-temperature, acid (HF) digestions. We report B isotope ratios in JB2 and IAEA-B5 standards obtained by different laboratories and chemical separation techniques, which reduces the discrepancies of reported δ11B data from TIMS, ICP-MS, SIMS and MC-ICP-MS documented in the 2000"s (Gonfianti et al., 2002) and even recent studies (e.g. Li et al., 2019). We will also present B isotope ratios obtained from MORB glassand scoria from the Chilean Andes obtained using Multi-Collecotor-Inductively-Coupled-Plasma-Mass-Spectrometry (MC-ICP-MS), demonstrating the significant improvement in B isotope analysis and its potential to resolve more subtle varaitions in B isotope records of low B samples. The newly obtained MC-ICP-MS data is compared with SIMS analyses of the volcanic glasses and melt inclusions in olivines from the same samples. The B isotopes of the bulk rock mafic scoria samples from Chile were analyzed via MC-ICP-MS and mimic the geochemical range derived from basaltic to andesitic/dacitic scorias (δ11Bvalues ranging from -8.59±0.23 to 3.98±0.08). These values are consistenly higher than subducted sedimentsand altered crust at depth, necessitating a heavy B isotope input, perhaps from subducted forearc modified melanges.

Uranium zonation refined U-Pb thermochronology – application to the Northern Andes of South America

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Uranium-Pb high-temperature thermochronometers (>350°C) exploit thermally activated volume diffusive loss of daughter isotopes in accessory minerals such as apatite, titanite and rutile. Previous studies have shown that U-Pb data can be used to generate accurate continuous t-T solutions spanning hundreds of millions of years. Single grain ID-TIMS analysis yields the highest precision, but detailed analyses of 238U/206Pb date vs diffusion length scales reveal scatter beyond predictions from volume diffusion. The causes of this scatter can be numerous, and include i) metamorphic overgrowths, ii) fluid catalysed Pb-removal, iii) parent isotope zonation, iv) metamictization, and v) changes in diffusion length. We compare single grain ID-TIMS with LA-MC-ICP-MS in-situ U-Pb dates, combined with trace element data (from Triassic leucosomes from the Northern Andes of South America), to examine the influence of parent isotope zonation on t-T information derived from apatite. Time-T-solutions from the in-situ analyses are corrected for parent zonation and compared with i) apatite 238U/206Pb ID-TIMS data, and ii) 40Ar/39Ar data obtained from muscovite and biotite from the same hand-specimen. Independently obtained t-T information from the well-established regional geologic history, and P-T estimates from garnet-plagioclase-quartz-muscovite/biotite assemblages are used to constrain maximum post-crystallization pressures and temperatures.

Tracking changes in weathering influx into late Ediacaran marine systems using lithium isotopes in carbonate rocks: An example from the Corumbá Group, Brazil

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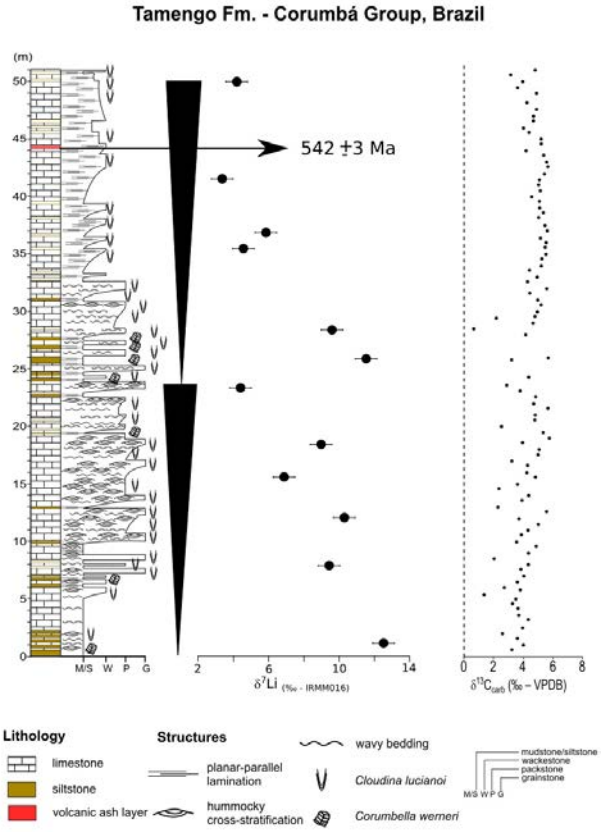
Biological innovations and the appearance of first complex organisms are remarkable episodes of the terminal Ediacaran. Several changes in Earth System were hypothesized as possible causes for such life movement to its complex forms, but they remain to be properly understood. Here we investigate the relationship between nutrient and alkalinity input into marine systems via chemical weathering and diversification of Ediacaran biota. To track changes in continental weathering, the Li isotope composition (δ7Li) of a marine carbonate section from the late Ediacaran Tamengo Formation (Corumbá Group, Brazil) was analysed using a SF-ICP-MS at the Geosciences Institute of University of Campinas, Brazil. The studied section is about 50 m thick and composed of two shallowing-upward cycles, alternating carbonate rocks and shales deposited in sub-coastal and mid to outer ramp environments. Several occurrences of the late Ediacaran index fossils Cloudina lucinoi and Corumbella werneri are recorded in these rocks. A volcanic rock layer at the top of the section was dated at 542 ± 3 Ma (U-Pb dating in zircon grains; Parry et al. 2017). The obtained δ7Li (IRMM) values vary between +12.5 and +3.5‰, defining two upward-decreasing trends that match the shallowing-upward cycles. Samples from the base of the first cycle yielded δ7Li values starting from +12.5‰ in rocks deposited below fair weather wave base level and decreasing to +4.5‰ in shallow environments. Similarly, values in the upper cycle decrease from +11.5‰ to +3.5‰ also from deep water to shallow water deposits. Our data suggest two shifts from incongruent to more congruent chemical weathering on continents, which may be related to mountain range uplifting and partial confinement of marine basins in (shallower) continental settings during final stages of West Gondwana assembly (ca. 550-530 Ma). Such changes in weathering style coincide with the occurrence of the first biomineralizing organisms of the Ediacaran fauna, suggesting an interplay between weathering influxes and life diversification. Uplifting would result in higher denudation rates and thus less 6Li and cation retention by clay formation on continents (congruent weathering).



A higher influx of cations is then delivered to the marine system, driving an increase in nutrient availability and overall alkalinity of the seawater, perhaps favouring biological secretion of aragonite. Other West Gondwana basins also display evidence of enhanced seawater alkalinity recorded on carbonate rock levels bearing Cloudina sp., reinforcing that high cationic influx into ocean via chemical weathering may have triggered biomineralization at the Ediacaran-Cambrian boundary.

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Geothermal systems exploration in the southern Chilean volcanic zone by magnetotelluric method

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Understanding the subsurface behavior of the Earth is of high importance for the development of geothermal

energy, especially in Chile, which has active volcanoes throughout the country. An area with great potential of geothermal development is the southern zone of Chile. Controlled by volcanic environment widely influenced by cortical fault systems. Several thermal spring manifestations of different temperature are proof of this control.
The study of geothermal systems in southern Chile began aroud of Villarrica volcano, thanks to the cooperation project funded by the Ministry of Education and Science of Germany (BMBF) and the government of Chile, with the objective of exploring reservoirs for the production of energy. The study in the area around the volcanic volcano was based on 31 magnetotelurica (MT) stations, deployed in two profiles, one oriented EW and perpendicular to the branches of the Liquiñe-Ofqui fault system (LOFS) and a second NS-oriented along LOFS and subsystems perpendicular to the Andean transversal fault (ATF) and the chain volcanic Villarrica-Quetrupillán-Lanín. The results correspond to inversion of MT data revealing a high anomaly of the electrical conductivity at 3km depth below the volcanic chain. In addition, anomalies of intermediate resistivity are observed that coincide with the location of thermal sources of low-medium temperature or monogenic volcanic activity. Possibly, fault systems would serve as fluid pathways.

The study of geothermal systems in southern Chile will continue with the investigation of the Tolhuaca geothermal system, located on the flanks of Tolhuaca volcano, influenced by LOFS and ATF as well. MT data measured in the surroundings of the Tolhuaca volcano will be analyzed, in order to know the influence of fault systems in a high temperature geothermal system.

These two studies will allow us to compare geothermal systems of different temperatures in the southern Chilean volcanic zone that are controlled by the same fault systems.

2D modelling of magnetic anomaly Tona on the Argentine continental margin

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ARGUS was a joint program between NRL (Naval Research Laboratory, U.S. Navy) and SIHN (Servicio de Hidrografia Naval, Argentine Navy), whose objective was to carry out a detailed survey of the Argentine continental shelf. The acquisition of data was done in two surveys one in 1991 and the other in 1993. Ghidella et al. (1995) carried out a series of processes to the data in order to obtain a magnetic anomaly grid, the analysis of this grid revealed two regions of markedly distinctive pattern separate by the „Colorado discontinuity“. The description of the anomalies was split in correspondence with this natural separation. In the northern zone, three remarkable positive lineations are possibly indicative of intense magmatic activity at the opening of the volcanic passive margin. One of these lineations is related to anomaly G (Rabinowitz y Labreque, 1979) and the others two lineations are on the shelf edge and on the platform, both of them bend somewhat towards the coast becoming highly intense at the south of the Colorado basin. This high-intensity pattern has been called „Tona anomaly“ that is abruptly interrupted at the Colorado discontinuity. Later Ghidella et al., made a 2D magnetic modelling over a profile and the Werner deconvolution. Afterwards they analyzed a 3D modelling (Abraham, 2005) obtaining as a conclusion that Tona anomaly has deep roots (~20 km) and the top of the bodies are located to ~6 km in depth, with a slope of 1.5º SW, which to the depth of 8 km become bigger: 4.6º; being the slope more abrupt in the other flanks (NW, SE). The purpose of this work consists in carrying out 2D magnetic modelling to the whole ARGUS lines crossing the Tona Anomaly, using an interactive program to estimate the coordinates of the bodies“ vertices and to use the Euler deconvolution to limit the depth of the sources. By the analysis of the results, we will do inferences about the bodies that compose the Tona and verify the conclusion obtained by the 3D analysis. In addition, we will infer the possible link to the south Atlantic opening or to a previous extensional episode.

Role of continental lower crust following the 2010 Mw 8.8 Maule earthquake: Insights from a power-law rheology model with dislocation creep

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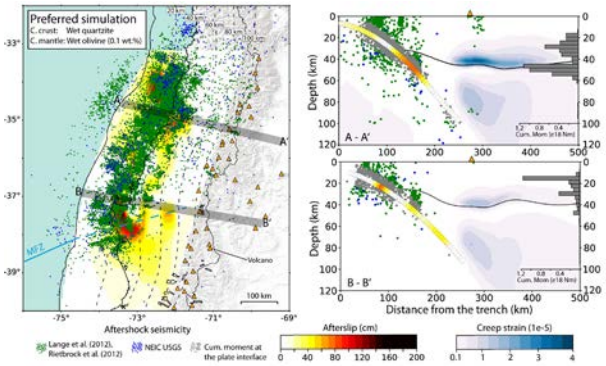
In the years following large magnitude earthquakes, the surface deformation is transient and occurs at high and variable rates decaying with time. This deformation is mainly a superposition of deformation processes such as afterslip and viscoelastic relaxation. The high data quality of continuous Global Positioning System (cGPS) stations recording surface displacements following the 2010 Mw 8.8 Maule earthquake has triggered a number of studies investigating postseismic deformation processes. These studies incorporate models that are either linear elastic or linear viscoelastic assuming that the whole crust is elastic. In this study we investigate the role of power-law rheology (non-linear viscosity) with dislocation creep for the crust and upper mantle on the postseismic deforma-

tion associated to the 2010 Maule earthquake using a 3D geomechanical-numerical model and six-year postseismic cGPS observations.



We first investigate the impact of possible dislocation creep parameters on the afterslip distribution from the inversion of the cumulative postseismic cGPS observations following the main shock. We find that afterslip distributions are sensitive to dislocation creep parameters. In particular, we find that the largest differences from simulations are found at depths > 60 km of the fault interface. As the root mean square error (RMSE) from our two best-fit afterslip distributions is not conclusive we compare the cumulative moment release from aftershock seismicity at the plate interface with the inverted afterslip distribution. The resulting viscoelastic relaxation from our preferred simulation mainly occurs in the continental lower crust as well as mantle lithosphere beneath the volcanic arc due to dislocation creep processes. In particular, viscoelastic relaxation in the continental lower crust reduces or eliminates the need of deep afterslip. Therefore, our results suggest that viscoelastic relaxation processes in the continental lower crust may be a key postseismic process following the 2010 Maule earthquake as well as its combination with the cumulative moment release by aftershocks may potentially better constrain afterslip inversions following megathrust earthquakes, especially its maximum depth.

A late Quaternary paleoecological record from Lake Petén Itzá, Guatemala: effects of abrupt climate change on aquatic and terrestrial communities in the lowland northern Neotropics

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Lacustrine sediment records that possess detailed, long-term data on past climate and environmental conditions are rare in the northern Neotropics. Exceptions include the sediment sequences from Lakes Chalco, Nicaragua, and Petén Itzá, which span multiple glacial/interglacial cycles. Lake Petén Itzá is a deep (zmax=165 m), large (100 km2) closed-basin karst lake in the lowlands of northern Guatemala that possesses a ~400-ka paleoecological record. It reacts sensitively to changes in the balance between evaporation and precipitation (E/P) and therefore has experienced dramatic changes in water level. This makes Lake Petén Itzá an ideal target for study of past aquatic and terrestrial environmental variability and to explore the ecological responses of aquatic and terrestrial communities to abrupt climate change in the lowland northern Neotropics.

We used the ostracode and pollen records from ~75.9-m-long core PI-6, Lake Petén Itzá, to explore biotic responses to abrupt climate and environmental changes during the last 85 ka. Detrended Correspondence Analysis (DCA) on fossil counts was used to assess the impact of climate change on aquatic and terrestrial communities by quantifying the magnitude and rate of ecological change of ostracode and pollen data, employing the R package „paleoMAS“. Temperature and E/P have been the main environmental variables shaping aquatic and terrestrial communities during the last 85 ka. Aquatic communities displayed larger ecological changes than pollen, as measured by SD, which may be explained by the relatively short life cycle of ostracodes. The crustaceans generally led changes in vegetation, indicating the faster response time of this aquatic community to environmental changes, relative to the response time of vegetation. We identified shifts with greater ecological changes in species during cold and dry Hs and the cold and wet Last Glacial Maximum. During Hs, numbers ostracode and pollen taxa decreased, however overall ostracode abundances increased, probably trigged by lower lake levels and expansion of littoral zones with abundant aquatic plants. Ecological change within the lake was especially high during H6 and H5. Rates of ecological change (SD/100 yr) were larger during Hs, and ostracode velocities mark perfectly the onset and end of each Hs, highlighting the high sensitivity and rapid response of these crustaceans to climate change. Ostracodes were not always present throughout the core, contrasting the continuous pollen record, which provided with important ecological and environmental information in the catchment, that otherwise would have remained unknown. Our results demonstrate the value of combining sedimented aquatic and terrestrial biological variables to explore the response

of terrestrial and freshwater aquatic communities to climate change in the lowland northern Neotropics.

Marine forearc structure of the 2014 Mw 8.1 Iquique earthquake revealed by hypocenter locations from offshore observations

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On April 2014 the Iquique earthquake ruptured with Mw 8.1 in the central part of a well-known seismic gap and left two smaller unbroken adjacent segments in northern Chile. This major earthquake and the large amount subsequent aftershock seismicity offer the possibility to study the heterogeneous structure of the marine forearc and to investigate the transition to the remaining unruptured seismic gap. From December 2014 until November 2016, we deployed two consecutive amphibious seismic networks of 15 Ocean Bottom Seismometers (OBS) that covered the Iquique 2014 rupture area and the adjacent unbroken region to the south. Besides the offshore data we use onshore stations from of the IPOC (Integrated Plate Boundary Observatory Chile) and CSN (Chilean Seismological Service) networks.

We present hypocenter locations detected using a local back-projection method integrated in SeisComP3. Arrival times and their quality estimates were further enhanced with MannekenPix (MPX) picking algorithm for first P-wave arrivals. Furthermore, we calculated double-difference hypocenter relocations based on waveform cross-correlations.

Most of the seismicity occurs between 19.5°S and 21°S up-dip of the maximum coseismic slip of the 2014 mainshock. The seismicity at seismogenic depths is highly focused forming well-defined clusters. The observed seismicity provides constraints on the structure of the marine forearc and the postseismic deformation. We relate the seismicity distribution to the background seismicity, seafloor morphology, and regional tectonics.

The Central and Southern Volcanic Zones of the Andes, what we know and what we do not know

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The Andean volcanism is represented by a great variety of volcanic structures, the formation of which depends on a number of variables. These include: the existence and characteristics of crustal reservoirs; rheological behaviour of the upper crust; age of the subducted oceanic crust; percentage of melting and assimilation of crustal melts; plate convergence parameters and conditions of the lithospheric mantle. Accordingly, the distribution of volcanoes is conditioned by these variables, resulting in the clustering of volcanoes in sectors where the conditions of storage, ascent and eruption are favourable.
The migrations and/or spatial propagation of volcanoes depend on both, the geotectonic variations (changes in the angle of subduction, subduction of asymmetric ridges, etc.) and crustal properties (variation in stress fields, existence of pre-Andean crustal anisotropies, etc.). Collectively, these boundary conditions determine the existence of the main volcanic arc parallel to the Andean axis, transvers volcanic chains, but also volcanic fields, the internal distribution of volcanic centres is apparently random.

Overall, the Central Volcanic Zone (CVZ: 18°-28°S) constitutes a rather wide orogenic system (the Altiplano-Puna), in which the differences between arc and backarc signatures of the magmas are currently debated. By contrast, the Southern Volcanic Zone (SVZ: 32°-46°S) is akin to a more conventional orogenic system and where the arc and backarc signatures are more apparent.

Composite and monogenetic volcanoes do not differ substantially in both of these volcanic regions. With their peculiarities, they respond to common processes that generate a spectrum of similar volcanic forms. However, collapse calderas differ notably both in characteristics and composition. Notably, collapse calderas of the CVZ are larger, compositionally homogeneous and widely spaced. Collapse calderas of the SVZ are smaller, more diverse in composition of their volcanic products and do not show final episodes of resurgence in their cycles, compared to calderas of the CVZ. The size and geometry of Andean volcanic fields also differ in both regions. In the CVZ, arc signatures can be recognized more than 300 km eastward of the main arc, whereas in most of the SVZ, the volcanic fields at equivalent distances from the arc display retro-arc or intra-plate signatures. The volumes of erupted magma (not taking into account the volume of equivalent intrusive bodies) during Cenozoic times are an order of magnitude larger in the CVZ than in the SVZ.

The differences in the characteristics of volcanism in both zones should be studied as effects of independent causes, conditioned by regional variables that require interdisciplinary studies. The existing databases of ages and geochemical compositions are limited and require an increase in basic information to improve local and regional interpretations. The classic cartography of volcanic centres is an indispensable tool in order to reconstruct the volcanic past and the characteristics of each volcano and, in the case of active volcanoes, allows to assess their potential hazard. In past decades, almost all volcanological schools in Latin America emphasized the need to understand the „personality“ of each volcano, which cannot simply be transferred to another volcano. This prevented, in multiple situations, the possibility of

grouping and quantifying processes in volcanic regions that allowed regional interpretations. That is why, in the coming decades, one of the challenges will be to find the causal relationships that govern similarities and differences in the Andean volcanic registers.

First qualitative observations and interpretation of fluid and melt inclusions from Capoeirana and Nova Era emerald deposits, Minas Gerais, Brazil.

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Emeralds, near Belo Horizonte, contains complex peculiar multiphase fluid/melt inclusions. Occuring in the Northern Part of the Iron Quadrangle, they are found in Qtz+Am-Phl-schist with+Chr, intercalated with Hc-Chr-Phl-Am-schists, amphibolites and quartzites in rocks of the Guanhães Complex, cutted by pegmatites of Amazonian and Brasiliano age. Probably three different tectonic events caused the structuration of this region, suggesting two emerald generations. At room temperature a CO2 phase (liquid + gas) between 40-60 vol% is associated with mineral grains; sometime also with a liquid. Mainly primary and pseudosecondary, are associated with silica rich solid inclusions containing the same carbonic assemblage suggesting heterogeneous trapping, remembering silicate glass inclusions described in topazite. The same assemblage is found in narrow capillary tubes (1-20µm in width and >800µm in length) in parallel alignment of primary origin. The carbonate rich inclusions have various shapes from 10µm up to >150µm, distributed parallel to the capillary tubes or in cicatrized fissures. The small quartz microcrystal formed after trapping have generally short knife shapes of 40 to 100µm, always with a solid carbonates attached to the base. Frequently the glass silicate inclusions have one ore more black dots, representing shrinkage bubbles. During heating the CO2 gas bubbles homogenized onto the liquid CO2 phase around 29-30oC, sometime showing critical homogenization. Generally the inclusions of both types (carbonic and silicatic) decrepitated around 300oC. On further heating some of the solid phases start to melt in a dark liquid phase supposed to be a carbonate liquid. Accidentally one carbonate inclusion containing (CO2 liquid + CO2 gas) do not decrepitated and after quenching from about 800oC showed the same fluid carbonic assemblage as before heating and this could be interpreted that the CO2 fluid phase was generated from the carbonate rich phase „in situ“ when the temperature reach the critical point. The same process may be involved after the initial trapping of the carbonate melt when the CO2 separate to CO2-liquid + CO2-gas phases with temperature decrease. The complex inclusions contain at room temperature carbonate and silica rich phases so can be presumed that at initial trapping conditions exist two immiscible melts, one carbonate phase and a silicate melt, indicating such a complex melt/fluid phase system during the emerald crystallization.

Volcano-tectonic analysis at the northern terminus of the Liquiñe-Ofqui Fault Zone (38°S): The Copahue Volcano, Argentina

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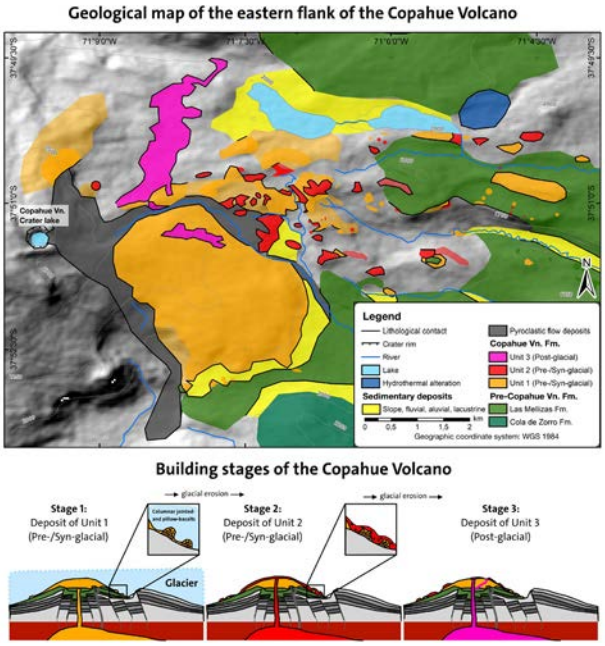
Copahue volcano, located at the latitude of 38°S, is one of the most active volcanoes in the Southern Andean Volcanic Zone. Situated around 30 km eastwards of the main magmatic arc and at the western margin of the 20 x 15 km Agrio Caldera, the volcano is part of the 90 km long NE-SW trending Callaqui-Copahue-Mandolegüe transverse volcanic lineament. The volcano is spatially associated with the NE-striking Lomín Fault, which is kinematically linked with the northern terminus of the Liquiñe-Ofqui Fault Zone. This peculiar position of the volcano prompted a number of studies to investigate the tectonic regime of the area and its possible control on the formation of Copahue volcano. However, the evolution of the volcano, notably the succession of the Copahue lavas - forming the volcano edifice - have received little attention. To remedy this deficit, the northern and eastern flanks of the volcano were mapped in detailed in terms of lithology and structure. Our study shows that the Copahue Volcano Formation consists of two main lava flows: A lower massive basaltic flow displaying columnar jointing, termed Unit 1, and an upper basaltic to andesitic flow, termed Unit 2. Both units are overlain by a minor blocky vesicular basaltic flow, termed Unit 3. Unit 1 appears to have covered a much larger area than evident by its present exposure. Individual patches of this unit represent remnants of an initially large lava flow, rather than individual subglacial vents, as interpreted by others. In contrast to previous studies, lithological contacts clearly demonstrate a deposition of Unit 1 prior to Unit 2, which requires revision of the volcanic stratigraphy. Moreover, glacial striations affecting both Unit 1 and Unit 2 indicate that both units were deposited before or during the last glacial period at these latitudes. The absence of glacial marks on Unit 3 indicates postglacial deposition of this unit. In addition, our field-based study did not reveal any evidence for a structural control generating the volcanic flows, as suggested by other workers. Collectively, our results permit a precise spatiotemporal reconstruction of the formation of Copahue volcano and may therefore aid in understanding better the history of the Copahue volcano and the associated

Agrio caldera. Detailed geological maps generated in the course of this study promise to be of importance for future studies.



Structure of the Argentine passive volcanic continental margin from 3D gravity modelling and isostatic calculations

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The Argentine volcanic passive margin (VPM) was developed between Rio Grande Rise and the Agulhas–Malvinas/Falkland fault between ~ 36º and 48ºS. Its formation began in the Late Jurassic/Early Cretaceous, starting in the South (approximately 49ºS) and gradually shifting to the North. The opening of the South Atlantic took place between approximately 137 and 126 Ma and was accompanied by extensive transient magmatism. Inherited crustal discontinuities generated during the period extending from the Transamazonian cycle (2300–1800 Ma) to the Gondwanic cycle (350–250 Ma) controlled in part the evolution and characteristics of the VPM. The VPM is ~ 60–120 km wide, depending on the latitude; presents seaward-dipping reflectors (SDRs) and has high-velocity lower-crust (HVLC) underplated bodies. Four segments (I, II, III and IV) were identified along the VPM separated by Transfer Fracture Zones (the Malvinas/Falkland, Colorado, Ventana and Salado Transfer Fracture Zones), which controlled the architecture, volume and width of the SDRs basaltic wedges.

With the aim of gaining insight into the VPM structure and evolution, we developed a 3D forward gravity model using IGMAS+ software, constrained by bathymetric, magnetic and seismic information. On the continental shelf and the Argentine continental margin, seismic, gravity, and magnetic studies were performed to describe and characterize the sedimentary basins and the ocean–continent transition. Particularly, 23000 km of multichannel seismic data, acquired and published by the Federal Institute for Geosciences and Natural Resources, (BGR, Germany) and 6900 km of multichannel seismic data, acquired and published from the National Commission on the Outer Limit of the Continental Shelf (COPLA, Argentina) were included as constraining data in our model. The bathymetric data consist of the depth and seabed topography, while seismic interpretation provided the depth and topography from crystalline basement, the full sedimentary thickness and its compressional wave velocities, SDRs and the HVLC bodies location and finally in some cross sections, depth and topography of the Moho. Densities assigned to the different bodies composing the 3D model were calculated from compressional wave velocities and extracted from previous published works. A very good fit between observed and calculated gravity anomalies was attained. Also, flexural and local isostatic calculations were carried out. Our results allowed to further investigate density distribution and thickness variations of the superstructures as continental, transitional and oceanic crusts along the VPM and to estimate the extension of magmatic underplating.

Extension of the Ordovician pre-Andean Famatinian arc in Northeastern Mexico: Peregrina tonalite

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The Precambrian and Paleozoic basement of the Laramidic Sierra Madre Oriental in NE is well exposed in the eroded core of the Huizachal-Peregrina Anticlinorium. It is composed by four different blocks in contact along sharp faults. Two metamorphic lithodems are the Neoproterozoic granulitic Novillo Gneiss complex, which belongs to the Oaxaquia Microcontinent and the Granjeno Schist complex, metamorphosed during the Carboniferous under green-schist facies and part of the Granjeno-Acatlán Belt. The third block is an incomplete strongly deformed siliciclastic sequence Silurian to Permian in age that comprises the highly restricted Tamatán Basin. The fourth block is represented by a plutonic body described ad Peregrina Tonalite (PTo), emplaced in the Novillo Gneiss and in tectonic contact to the Granjeno

Schist. PTo was described early as an orphaned block associated with an enigmatic Carboniferous magmatic arc located along the NW margin of Gondwana. Major and trace element concentrations and ratios of PTo indicate a link to a continental arc developed along Gondwana´s NW margin. New U–Pb LA–ICP–MS data from PTo zircons included a youngest Late Ordovician (Katian stage) population at 448.8 ± 2.9 Ma, interpreted as the crystallisation age, and an oldest Grenvillian population interpreted as the potential age of its protolith. We propose a comprehensive model for the evolution of the NE Mexican basement without the involvement of exotic or orphaned terranes. Peregrina Tonalite represents an new reported magmatic arc in NE Mexico established during the Late Ordovician, described as the Peregrina–Mochonian Orogeny. It represents an extension of the Chiapas Mochonian Orogeny (in S México) and the South American Famatinian arc into NE Mexico.

Tortonian trachyte volcanoe in the Alta Sierra de Somún Curá Volcanic Complex. Northern Extrandean. Patagonia. Argentina

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The Miocene Alta Sierra de Somún Curá Volcanic Complex (ASSCVC) is the northernmost post-plateau complex of the Somún Curá Magmatic Province (SCMP), at the northern extrandean Patagonia, Argentina (Fig. 1a, b).

ASSCVC is made of several volcanic buildings which span the basaltic to trachyte realm. Monogenetic basaltic volcanoes (i.e. Cuatro Cerros), trachyte apparatus (i.e. Cerro Pancho) and polygenetic basaltic to trachyte constructions (i.e. Cerro Corona) compose the Complex. Four features distinguish ASSCVC from other postplateau complexes of the SCMP: its age, it is the youngest of the post-plateau assemblages; the lack of a compositional gap between basaltic and trachyte terms; the absence of rhyolite differentiates and the presence of several emission centers associated with prominent volcanic constructions.

This contribution deals with one of the chiefly trachyte volcanoes of ASSCVC. The polygenetic stratovolcano of Cerro Mimbre (CMTV), located in the southern complex (Fig. 1c), is the northernmost of three volcanoes arranged along a NW-SE trend. CMTV is set within a local low relief area dominated by volcanic landforms with general SE gentle slope. Two semicircular escarpments in the uppermost CMTV are compatible with an explosion crater. Associated loose deposits of white color and fine texture, located among coulées, are indicative of explosive eruptive facies. At least four lobular trachytic coulées emerge from the domes distributed in the CMTV; coulées locally preserve marginal ridges. Trachyte coulées include autobrecciated facies of porphyric texture with anorthoclase phenocrysts and minor

ferromagnesian minerals. Groundmass is trachytic composed of sanidine microliths and clinopyroxene. Trachyte lava flows are porphyric with feldspar phenocrysts (of oligoclase to anorthoclase composition) set in a trachyte groundmass with some bostonitic patches. Microliths of anorthoclase to sanidine composition, olivine, clinopyroxene (Mg-rich augite), F-apatite and magnetite complete the groundmass assemblage. Two long basaltic flows extend for several kilometers enveloping the CMTV. Three scoria cones surround the

CMTV; within the main crater, there are two oxidized deposits of scoria that would correspond to a very eroded cone, younger than the trachyte coulées. The lowermost basaltic flows surrounding the main volcanic building are vesicle rich, either aphyric or porphyritic with plagioclase phenocrysts and olivine microphenocrysts set in an intergranular groundmass with ophitic patches made of clinopyroxene and plagioclase. Trachyte flows of the CMTV yielded a new whole rock K/Ar age (Fig. 1d) of 9.8 ± 0.3 Ma, which fits well (within errors) with already published chronological data for other trachyte lavas of ASSCVC (? 9-13 Ma).

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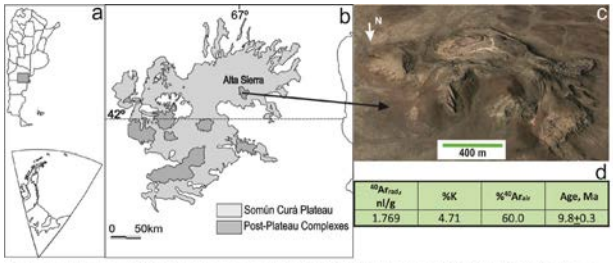

$^{40}Ar_{rad}$, nl/g	%K	$\%^{40}Ar_{air}$	Age, Ma
1.769	4.71	60.0	9.8±0.3

Fig. 1: a) Location map of SCMP in Argentina; b) general sketch of SCMP with indication of ASSCMC; c) Google Earth image of Cerro Mimbre Trachytic Volcano; d) Analytical data of whole rock K/Ar age of Cerro Mimbre trachyte.

Electrical structure of the Andean orogenic crust in Northern Chile at 23°S using magnetotelluric data

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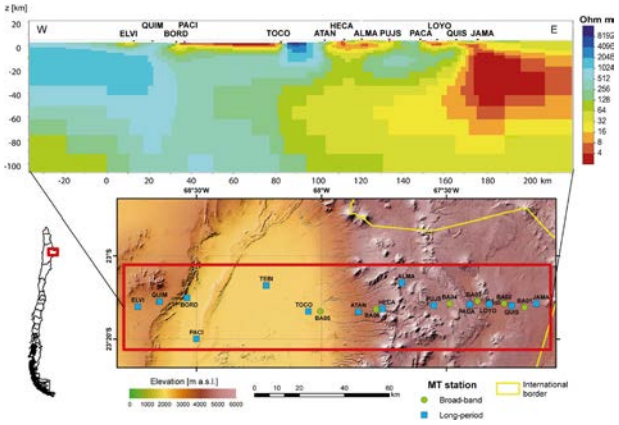
Subduction is a long-term process at the Chilean margin. Its occurrence has determined the development of magmatism and deformation. For this reason, the Central Andes have been a subject of several geophysical and geological studies over the last decades.

The magnetotelluric method (MT) is a technique which measures the variations of terrestrial electromagnetic fields and relates them by parameters called impedance tensor and induction vectors, which are sensible to spa-

tial variations of electrical conductivity. Thus, MT is useful for imaging hydrothermal alteration, magmatic systems and fault systems.

The study area is located in Chile at 23°S latitude. 14 long period MT stations (LMT) and 6 broadband MT stations (BMT) were deployed in the Domeyko Range, Pre-Andean Depression, Western Cordillera and Puna. The profile has a W-E orientation and an extension of 170 km. LMT stations were located every 10 km; however, the lack of proper access and bad soil quality led to a worse spatial coverage at the Salar de Atacama (SdA) basin and Western Cordillera. BMT stations were placed between LMT measurements in the Puna and the eastern margin of the SdA.

Two 2D inversions were carried out using WingLink software. The first inversion result used the LMT data and shows two contrasting domains. The Western domain (WD) is characterized by a resistivity >1000Ωm coinciding with a zone that was previously described as a cold lithospheric block with high density, high seismic velocity and low seismic attenuation. This domain is spatially correlated with the occurrence of Paleozoic intrusives. A 55 km long high conductive zone (HCZ), reaching the depth of 4 km and resistivity values <10 Ωm, appears where the SdA is located. The Eastern domain is dominated by HCZ. The greatest anomaly can be related to the so called Altiplano Puna Magma Body which has been interpreted as a MASH zone related to the Neogene Altiplano Puna Volcanic Complex (APVC). Along the profile two manifestations of the APVC occur: the Purico Volcanic Complex (PVC) and La Pacana caldera. The PVC has a high conductivity from 0 to 8 km, meanwhile the La Pacana caldera shows a 300 Ωm anomaly from 12 to 22 km.



The second inversion uses the BMT data. It images several HCZs with resistivity ranging between 1 and 20 Ωm appear. They can be associated with magmatism and hydrothermal alteration zones.

For the further work, 3D inversions are being performed using ModEM algorithm and previously measured data.

LCT and NYF pegmatites as an indicator for the magmatic evolution of the Las Chacras Batholith, central Argentina

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The Devonian Las Chacras Batholith in the Sierra de San Luis in central Argentina show a complex system of six granitoid intrusions. The intrusions are emplaced along a pull-apart structure in the Ordovician basement, which is composed of metasediments and S-type granites. The individual plutons are divided by different geochemical signatures and ages (Siegesmund et al., 2004).

Intra-granitic pegmatites occur in all units of the Las Chacras Batholith but are most abundant in the south. Some of the pegmatites reveal NYF-type mineralization (Nb-, Y-, REE-, F-rich phases; Lira et al., 2012). In contrast, the pegmatites of the Ordovician basement are of LCT-type mineralization (Li, Cs, Ta).

Coeval intrusions of stocks and dikes of lamprophyres demonstrate a strong mantle component in the Devonian magmatism. The granitoid intrusions show a north to south directed increase in magmatic differentiation and crustal contamination, as indicated by radiogenic Sr/Nd-isotope ratios (López de Luchi et al., 2017).

The present work investigates the mineralogical and geochemical composition of the pegmatites and the granitoid hosts as its sources to provide new insights into the evolution of the magmatic system and the development of the NYF mineralization.

The present study focuses on the emplacement and the evolution from primary melts at different structural levels within the crust to differentiated residual melts as a carrier for high-technology elements. In order to compare the different sources, melt contamination and fractionation processes, such as assimilation, mixing and mingling, major and trace element analyses as well as boron isotopes on tourmalines are used.

First field and geochemical evidence point to a strong influence of the syn-magmatic mafic mantle-derived melts on the granitoids and therefore pegmatoid composition.

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Insights on the lithospheric density structure of the Southern Central Andes and their foreland

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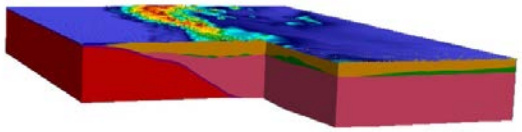
In a subduction setting, the overriding plate structure is one of the major controls in the formation of strong and weak areas within the crust, affecting the localization and extent of deformation. In the case of the Andes, the orogeny is caused by the subduction of the Nazca oceanic plate beneath the South American continental plate. Previous studies aimed to constrain lithospheric-scale density and structural heterogeneities in the Southern Central Andes, in the Puna and the Chaco-Paraná basin (~20 - 27°S). This study focuses on the southernmost segment of Central Andes (~27° - 40°S), characterized by a strong N-S and E-W variation in the crustal deformation style and intensity.

We present a characterization of the present-day state of the lithosphere, regarding the density variation and configuration of the sediments, crust and mantle by building a lithospheric-scale model consistent with both the available geological and seismic data and with the observed gravity field. A gravity forward modelling was carried out using IGMAS+ (Götze and Lahmeyer, 1988; Schmidt et al., 2010). The model consists of a continental plate with sediments, a two-layer crust and the lithospheric mantle being subducted by an oceanic plate (Fig.1). The configuration of sediments, crystalline crust and lithospheric mantle was constrained by the geological and seismic data, while the intracrustal discontinuity was modified in order to reproduce the observed gravity field. Besides being able to assess the geometry and composition within the lithosphere, the resulting model allowed us to evaluate the isostatic state of the crust.

This is a first step on the way to estimate the thermal and rheological state of the lithosphere in the overriding plate to further investigate the link between its compositional, thermal and rheological heterogeneities with the geometry of the subducting plate and the deformation style.

This project is supported by the International Research Training Group StRATEGy.



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Evidences of early Holocene glacial advance in Lachman Beach, James Ross Island, Antarctica; and high latitude linkages in southern hemisphere

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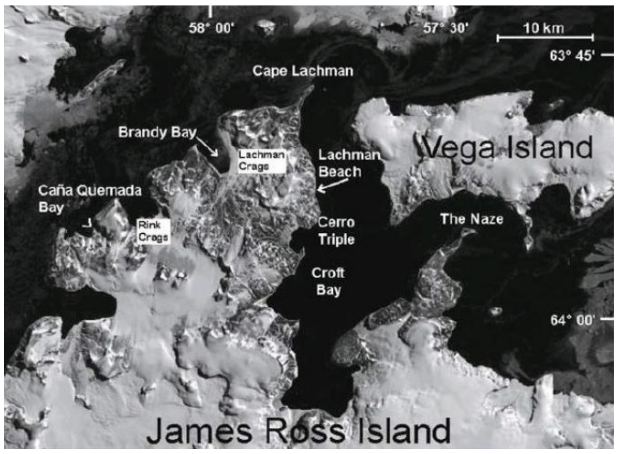
A recent stratigraphic survey on marine terraces in James Ross Island (JRI), northwestern Antarctic Peninsula (AP), provides evidences of early Holocene glacial advance. Several profiles of this glacial transgressive/regressive sequence were performed and sampled for radiocarbon dating (delta R= 829 ± 50), yielding minimum age of 7100 and maximum age of 7300 cal yrs BP for this glacier advance. The highest early Holocene marine terrace of JRI reaches up to 17 m.a.s.l, documenting the rapid isostatic uplift that produced falling relative sea level (RSL) for early Holocene after 8000 yrs BP (Hjort et al., 1997). The deglaciation is not only evidenced in terrestrial records from Lachman Beach but also in high resolution marine-core sediment records from Croft Bay, concluding that the bay was fully deglaciated by 7200 yrs BP (Minzoni et al., 2015). According to new age interpretation of southern Potter Cove, King George Island, the Holocene postglacial marine transgression initiated before 7650 yrs BP, and was locally interrupted by a glacier advance about 200 yrs later, shortly after 7285 yrs BP (Strelin et al., 2014a). Combining evidence from isolation basins and raised beaches, a new RSL curve was reconstructed for Fildes Peninsula, which fell after 7500 yrs BP as a consequence of isostatic uplift in response to regional deglaciation. However, a temporary pause in glacial isostatic rebound was found around 7200 yrs BP indicating a glacial advance close for this site (Watcham et al., 2011). Evidences for a less extended early Holocene glacier ad-

vance were also detected in Península Herminita and in Agassiz Este Valley, in Patagonia, which can be related with glacial advances in New Zealand for the same age (Strelin et. al, 2014b). These robust evidences, make onland stratigraphic records from James Ross Island an important tool to complement other geochronology methods in order to have a broader perspective on past ice sheet dynamics; not only in Antarctica, but also in other high latitude regions.



Bacterially reduced sulfur in organic-rich facies of early Eocene red-beds (Cuzco region, Peru) as trap for copper during migration of basinal fluids

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The Tambomachay ore deposit (13°28'36.78"S, 71°57'35.98"W, about 6 km to the north of the town of Cuzco - Peru) consists of Cu hosted in the upper part of the Kayra Formation (Lower Eocene), the oldest unit inside the Early Eocene – Early Oligocene red-bed sequence known as San Jerónimo Group (Carlotto et al., 1996, 2011), that overlies Cambrian – Paleocene sedimentary rocks and is interpreted to be deposited in a fluvial environment in a foreland basin of the Western Cordillera of the Central Andes (Carlotto et al., 2011). The Kayra Formation consists of red arkosic sandstones, displaying cross-bedding in places, with some intercalations of greenish gray fine grained sandstones or greywackes. This twofold lithology corresponds to different sedimentary domains of an alluvial system. The red sandstones represent permeable fluvial sand bars and channels, allowing post depositional fluid circulation. The greenish gray greywackes rather stand for flooding plain organic-rich deposits in a swamp-like environment that prevented surface oxidation (Rosas et al., 2019).

Bornite, chalcopyrite, chalcocite, covelite, digenite, malachite, and chrysocolla occur cementing veinlets, intergranular pores and other open spaces in the greenish gray fine grained sandstones or greywackes of the Kayra Formation. The main control for the ore deposition is a local fault, whose fault plain is „carpeted" by copper sulfides.

The occurrence of the copper ores in a green reducing horizon intercalated in the red bed sequence, the presence of organic matter in interstices between the hypogene sulfides, and the sulfur composition of the copper sulfides (δ34S values between -16.9 and -12.4‰ vs VCDT) pointing to bacterial sulfate reduction, are strong arguments to propose that mineralization was caused by copper-bearing oxidizing saline basinal fluids that precipitate copper sulfides when they meet reduced sulfur in an organic matter-rich horizon.

A local fault and other regional structures as the „Falla Tambomachay" could have acted as feeders for oxidizing basinal copper-bearing fluids that precipitated copper sulfides in reduced horizons of the Kayra Formation. Fluid migration was probably driven by tectonically-induced topography gradient.

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Paleomagnetism of Middle-Late Jurassic Bahía Laura Group (Patagonia, southern Argentina)

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In the present work, the results of the paleomagnetic analysis of the Chon Aike and La Matilde formations, which make up the Bahía Laura Group, are shown. These units are assigned a Middle-Late Jurassic age (Pankhurst et al., 2000, Feraud et al., 1999). Because both units are mainly composed of tuffs, ignimbrites, and rhyolitic lavas, it is very difficult to establish a stratigraphy of both, and in some places, they seem to be interdigitated and in others, it seems that one underlies the other. Unlike the ignimbrites of the Chon Aike formation, the tuffs and ignimbrites of the La Matilde Formation show a certain degree of inclination in the studied outcrops. This is confirmed by its magnetic fabric by studying the Anisotropy of Magnetic Susceptibility (AMS). However, the paleomagnetic directions coincide with each other without applying any tilt correction, despite the different magnetic fabric or inclinations of the rock . For this reason,

it is interpreted that the ignimbrites of the La Matilde Formation were adapted to the terrain and to the morphology prior to depositing, because, if a tilt correction is applied, the paleomagnetic directions are dispersed instead of grouped. The results of the paleomagnetic study show that the paleomagnetic pole of the La Matilde Formation and the paleomagnetic pole of the Chon Aike Formation are equivalents. Both paleomagnetic poles pass a reversal test, in to validate their statistical parameters. Therefore, both formations were formed in a similar time interval (150-160 Ma) and did not undergo vertical rotations of tectonic blocks. This shows that the Deseado Massif already made Patagonia as it is today, since at least the Middle Jurassic that it was constituted as a whole by then.

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Somún Curá Magmatic Province (Argentina). Lava-pyroclastic sequence southern of El Cain village: Age and composition.

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The volcanic sequence of the Somún Curá Magmatic Province (SCMP) occupies large areas in the south of Río Negro Province and north of Chubut Province, Argentina. SCMP encompass a great variety of basaltic volcanic associations in the north of extrandean Patagonia.

The western region of the SCMP is characterized by the stratigraphic complexity including a large time range, a recurrent magmatism and several petrogenetic lineages. In the north of the Barril Niyeu Volcanic Complex (BNVC) (Fig. 1 a; b), one of the most important bimodal associations of the PMSC, and to the south of El Cain village, a sequence of lava and pyroclastic rocks outcrops (Fig. 1 b). These exposures record two basaltic events separated by a time gap, currently evaluated only based on stratigraphic relationships. Further estimations are provided by newly acquired radiometric dating, which are the focus of this contribution.

The oldest basaltic event is represented by a fine grained rock of intersertal texture, with plagioclase in a fluidal arrangement, olivine, clinopyroxene and opaque minerals, and significant zeolitization. A whole rock K/Ar age of basalt flow of this unit yielded 53 ± 2 Ma. Resting over this basalt there are fall deposits and pyroclastic flows with discontinuous intercalations of pyro-epiclastic deposits assigned to the Sarmiento Group (Oligocene). This sequence is >70 m thick and constitutes prominent cliff covered by a new episode of basaltic lavas that forms a plateau which frames the southern sector of the El Cain depression. The flows, originated in an apparatus located 13km to the west, are light gray basalts with vesicular roofs and average thickness of 5 m. Rocks are porphyric traquibasalts of fluidal texture, with plagioclase, titaniferous augite, iddingsitized olivine and interstitial alkali feldspar. This rock, yielded a whole rock K/Ar age of 18.7 ± 0.4 Ma, that represents the youngest age of the BNVC effusions.Therefore, the radiometric dating constrains the BNVC activity between the Eocene (Ypresian) and the Miocene (Burdigalian). Although these ages correspond to a very restricted area of the PMSC, the correlation with regional events allows to extrapolate this time range to a wide area of the western sector of this Province. The Palaeogene volcanism is represented by several necks of the Cerro Cortado Fm., El Buitre Fm. and equivalents, which have been correlated with the basalt outcrops of Basalto Pilquiniyeu in the west of the PMSC. The oldest basalt in the studied profile correlates with this magmatism that extends between the Paleocene and the Eocene with a climax in the Early Eocene. In addition, the most modern events correspond to episodes linked to large bimodal complexes such as Barril Niyeu, Apas, Talagapa and Pire Mahuida (Fig. 1 a).

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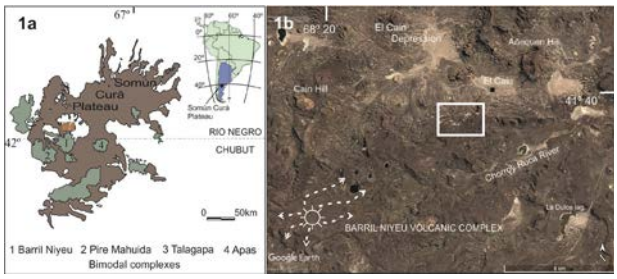

Fig. 1: a) Location map showing the Somún Curá plateau and the bimodal complexes. The studied area is represented by an orange rectangle. b) Close up view of the El Caín area. At left sector of Google Earth Image is located the volcanic center which originated the basaltic flows. The rectangle encloses the outcrops of the studied sequence.

Lithium sources in northern Puna salars, Argentina. Evidence from Li and Sr isotope compositions.

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The „Lithium-Triangle“ region is located in the high Puna-Altiplano Plateau of the central Andes (27° to 21° S). In this area, high-altitude endorheic basins (salars) contain the richest known brine resources of the Li in the world.

In this work, we study Jama and Mucar salars (northern Puna). They developed within the same basin, separated by a range of Ordovician sedimentary rocks. With the aim of understanding the source of Li, we obtained Li and Sr isotopic ratios from rocks, brines, salts and river waters. Li isotope compositions reflect low temperature fractionation processes, during weathering or hydrothermal leaching of the source rocks, where Sr isotope ratios report contrasting signatures of potential source rocks e.g. Cenozoic volcanic and Ordovician sedimentary rocks.

Water and brine samples show positive δ7Li values between +3 and +15 ‰ and 87Sr/86Sr values between 0.709 and 0.712, while the Li concentrations are between 0.03 and 245 mg/L. Salt samples also show positive δ7Li values but in a narrower range. Their 87Sr/86Sr are mostly in the same range as in the fluid samples. The Li concentrations are higher in the salts, between 471 and 1253 µg/g. Clay and sand samples show negative δ7Li values between -9 and -6 ‰ and an average 87Sr/86Sr of 0.711. The Li concentration in clay and sand, varies between 40 and 156 µg/g, being higher in the clay. Cenozoic volcanic rocks show δ7Li between -5 and +1 ‰, 87Sr/86Sr between 0.709 and 0.715 and average Li concentrations of 39 µg/g. Palaeozoic basement rocks have a higher average Li concentration, δ7Li between -5 and +6 ‰ and 87Sr/86Sr between 0.717 and 0.914.

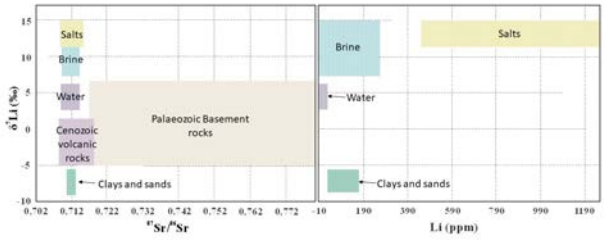

Figure 1 shows the data presented above. During weathering a preferential fractionation of 7Li into the solute occurs, leaving a silicate phase enriched in 6Li (salar sediments with light, negative δ7Li). The difference in Li concentrations between water, brine and salt is related to evaporation processes. The wide δ7Li range displayed by the runoff water is likely due to the different extent of Li fractionation in the weathering of the source rocks. The δ7Li is not substantially fractionated between brine and salt, i.e. halite crystallization. The 87Sr/86Sr ratios of brines/water and salts, that overlap with the range of Cenozoic volcanic rocks and indicate an important contribution of the latter to the runoffs collected by these endorheic basins. The flux from sedimentary Ordovician basement rocks seem to be of minor importance.

The role of mass wasting in glacial forelands of the Andes

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Large segments of the Andean foreland have been repeatedly shaped by Quaternary glaciations. The many diagnostic landforms include large glacial lakes, staircases of moraine ridges, and extensive outwash plains, and have inspired generations of Quaternary geologists to reconstruct the processes, magnitude, and timing of ice build-up and decay along the mountain front, adding to a reference chronology of Southern hemisphere glaciations. What only a few of these studies have noticed are several hundreds of very large (>>106m3) mass-wasting deposits that fringe the Andean foreland. Many of these debris mounds intersect with many well-dated moraine ridges or former meltwater-lake shorelines and offer exciting opportunities of exploring the hitherto largely unknown role of mass wasting in the glacial forelands of the Andes. More than 283 large rotational slides and lateral spreads followed by debris slides, earthflows, rotational and translational rockslides, complex slides and few large rock avalanches detached some 164 ± 56 km3 of material along the former Lago Buenos Aires and Lago Puyerredón glacier lobes and lakes in Argentina. In this study we focus on a small area along the western side of the volcanic plateau Meseta del Lago Buenos Aires and present a detailed study showing periodic peat slides and earthflows on top of an reactivated rotational landslide.

Dynamic interaction of the initial impact melt sheet during peak-ring formation of the Chicxulub Impact Crater, México.

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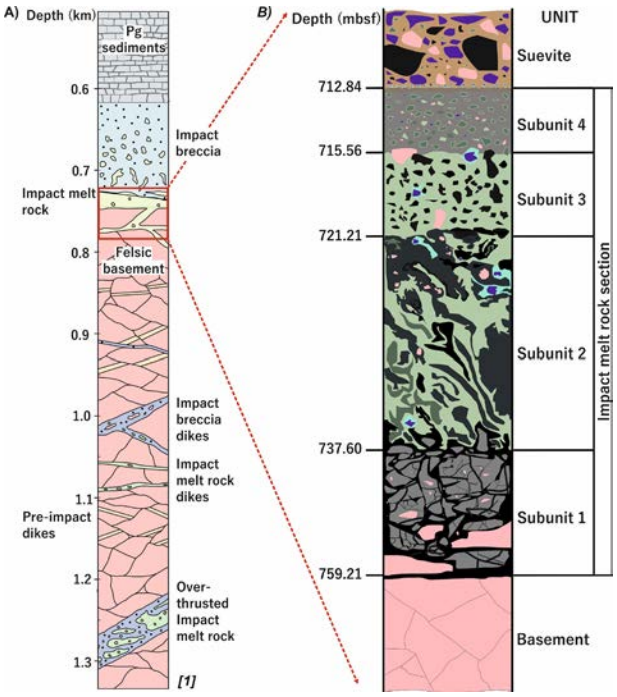
IODP-ICDP Expedition 364 drilled into the peak-ring of the 66 Ma, 200 km-Ø Chicxulub impact crater, México. Coring started at 500 meters below sea floor (mbsf) and includes ~120 m post-impact sedimentary rocks above a ~ 140 m thick suevite and impact melt rock unit. Beneath 575 m pervasively shocked granitoid basement rocks, intersected by pre-impact dykes and suevite bodies, make up the drill core to its final depth of 1334 mbsf. Based on visual inspection of line scans, microstructural and electron microprobe analyses, we focus on the emplacement processes of a layered impact melt rock section on top of the basement rocks (Fig. 1) to examine the individual melt dynamics during solidification, deposition of the overlying suevite unit and ongoing peak-ring settling.



The melt rock can be divided into four subunits, which are from bottom to top: 1) A ~21.5 m thick subunit is composed of a fragment poor, aphanitic silicate melt rocks. Besides the homogeneity of the melt rock composition, the characteristic feature are macroscopically visible mottled textures with jigsaw geometry. These observations indicate, that the melt rock represents a quenched and auto-brecciated remnant of the initial homogeneous melt sheet, which is consistent with petrographic analyses from previous drill cores. 2) A ~16 m thick subunit is made up of interlayered silicate and carbonate rocks displaying convoluted centimetre-scale folds. The predominantly aphanitic silicate melt rocks are similar to the lowermost subunit. The rocks are composed of secondary clay- and sparitic calcite. Cusp-and-lobe geometry indicates that the silicate phase was more viscous than the carbonate phase during folding and solidification. 3) A ~ 6 m thick subunit is composed of a melt breccia, hosting subangular fragments of silicate rocks. The groundmass is similar in composition to the carbonate rocks below, but shows little evidence for ductile flow. 4) A ~ 3 m thick subunit is separated discordantly from the overlying suevite and is composed of ~ 0.5 cm thick target rock fragments showing resorbed margins, set in a brecciated calcareous matrix.

The consolidation of the silicate and carbonate rock structure above a homogeneous melt rock points to modification or mingling of the initial melt sheet with an external source from the top downward. This is consistent with an observed thermal gradient, evident by the upward directed decrease in viscous flow and onset of brittle deformation in the silicate rocks. The structural characteristics of the melt rocks point to quenching by the entrained phase from the top along a perturbed interface. The layers appear to have developed during peak-ring settling at a shear interface between impact melt at the base, superimposed on basement elevating outward from the crater centre and water-saturated target material at the top slumping into the crater.

Fig. 1: (A) Lithology of Exp. 364 drill core, slightly modified from: [1] Morgan J. V. et al. 2016. The formation of peak rings in large impact craters. Science 354:878-882. (B) Cross section of the layered impact-melt rock subunits.

Upper plate stress field in the northern Chile forearc from earthquake source mechanisms

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Subduction zone forearcs deform transiently and permanently due to the frictional coupling with the converging lower plate. Transient stresses are mostly the elastic response to the spatio-temporally variable plate coupling through the seismic cycle. Long-term deformation depends e.g., on the plate convergence geometry, where obliqueness or change in obliqueness play important roles. Here we use the Integrated Plate Boundary Observatory Chile (IPOC) and additional temporal networks to determine source mechanisms for upper plate earthquakes in the northern Chile subduction zone. We find that earthquakes in the South American crust under the sea and under the Coastal Cordillera show a remarkably homogenous north-south compressional stress field. Earthquake fault mechanisms are dominated by east-west striking thrusts. Further inland where the lower plate becomes uncoupled, the stress field is more varied with direction east-west to southeast-northwest dominating. The peculiar stress regime almost perpendicular to plate convergence direction may be explained by a change in subduction obliqueness due to the concave shape of the plate margin.

Hydrogeochemistry and origin of elevated concentrations of fluoride, arsenic and uranium in the area of the San Antonio el Grande mine, Chihuahua / Mexico

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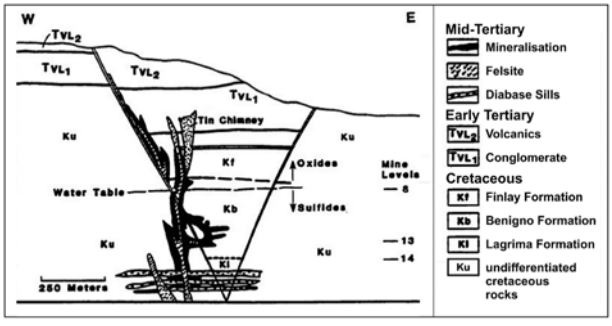
The dissolved trace element concentrations in groundwater and surface water in the study area around the mine exceed the German Drinking Water Regulations of 1.5 mg/l for fluoride, 10 ppb for arsenic and 10 ppb for uranium in 72.8 %, 64.0 % and 58.4 % of all samples.

The groundwater, as the region's most important drinking water source, is threatened by the elevated concentrations and to address the question of the origin and the underlying mobilisation and transport processes, the element distributions of 125 water samples were examined and evaluated with regard to their main and trace elements.

The incompatible elements accumulated in the course of magma differentiation in the predominantly acidic igneous rocks of the investigated area and solution processes depending on pH value, temperature and redox potential were identified as the main source for the increased concentrations in the waters around the mine. In addition, the numerous mineralisation zones and the carbonates, such as limestones, that occur frequently in this region represent further potential sources. The mobility of the trace elements fluoride and arsenic seems to be mainly controlled by the pH value. Alkaline pH values cause higher concentrations. Especially for the mobility of uranium the water temperature seems to be a decisive factor. However, the dissolved fluoride concentration in the water is also increased by higher temperatures. Fluorite precipitation, on the other hand, does not seem to be a decisive control mechanism.

The San Antonio mine increases the dissolved trace element concentrations in the waters by creating larger contact areas with the acidic igneous rocks and new pathways. The constantly decreasing groundwater level will lead to further problems in the future. It is likely that more and more deep water will be pumped, which could further increase the content of dissolved trace elements. In order to ensure the long-term security of the drinking water supply in the study area and to protect the population from the potentially human-toxicological trace element concentrations, efforts should be made to reduce the dissolved contents. A possible precipitation of fluoride via the mineral fluorite could be considered.



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Structure of and dynamic processes within the crust of Northern Chile (IPOC area) based on ambient seismic noise correlations and repeating Earthquakes

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Active tectonics in Northern Chile in conjunction with the exceptional seismic and geodetic instrumentation provides a unique opportunity to study the structural and dynamic circumstances of large subduction zone earthquakes. We focus on the 2014 earthquake sequence that culminated in the Mw 8.1 Iquique earthquake on April 1st. This sequence includes a rich foreshock sequence a large mainshock followed by numerous aftershocks.

To establish the structural background in which we investigate the dynamic processes that proceed, accompany and follow major earthquakes we perform an ambient noise tomography of the shallow crust in the area of the IPOC network. We use a hybrid approach comprising of a linearized inversion of group velocity curves for group velocity maps and a Markov chain Monte-Carlo inversion of local 1D dispersion curves obtained from the group velocity maps for the final 3D s-velocity structure. Our model contains the top 10km of the crust with a lateral resolution of about 30km where the first order features are two shallow N-S striking bands of high and low velocity anomalies along the costal cordillera and the central depression, respectively. The low velocity structure along the Atacama Bench is segmented with pronounced minima located about 19.5˚S, 20.8˚S and 22˚S.

To investigate the expression of dynamic processes in the seismic velocities we follow two strategies. On the one hand we use records of the ambient seismic field for continuous monitoring of the velocity variations. This revealed the response of the shallow subsurface in the vicinity of the seismic stations to earthquake shaking and subsequent healing as well as fluctuations of temperature and variations of tidal forces from sun and moon.

On the other hand, using repeating earthquakes that occurred in more than 500 distinct clusters containing up to 50 events we investigate signals that have sensitivity to medium changes close to the source volume of the events. Observed velocity changes with amplitudes of 0.001% are tiny but often accurately observable due to the high coherency of the repeating earthquake signals.

Earthquake scaling models applied to seismicity analysis in Chile

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In order to analyze the huge amount of seismic data from Chile seismic region gathered by new instruments deployment and due to large events in the last decade, we

studied the scaling properties of local seismic catalogs. We use the scope of the Unified Scaling Law for Earthquakes (USLE, Bak et al 2002). It states that the density probability function of the inter-occurrence times, as they are counted in hierarchical cells of magnitude and linear dimension, have a scaling functional form. The b-value of Gutemberg-Richter law and the fractal dimension of the distribution of earthquake epicenters appear as critical indices. We‘ve shown that in a local seismic catalog calculated with body waves (Derode et al 2019) this law hold. A parameter estimation is made using a box-counting algorithm (Nekrasova et al 2015). This parameter estimation is then used to characterize chilean seismic regions.

We have developed a conceptual model from complex critical systems in which this analysis is framed. The Unified Scaling Law for earthquakes emerges in a simulation of a cellular automaton, in which arrangements of site-blocks coalesce according to their coupling and rupture in cascades to generate seismic events. Emergence arise from the geometrical definition of the system and the criticality it is posed in.

With this study we put in evidence the necessity of having actualized and well maintained seismic catalogs, that can account for robust parameter estimations and can later be used to provide reliable hazard estimation.

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Filling the gap in a double seismic zone: Intraslab seismicity in Northern Chile

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Double seismic zones (DSZs) of intermediate-depth intraslab seismicity are observed in many subduction zones around the globe, and have been related to dehydration reactions in the downgoing crust and mantle lithosphere. These reactions occur at, to first order, constant temperatures, which explains the observed linear arrangements of seismicity that appear to follow isotherms of thermal models.

Intermediate-depth seismicity in Northern Chile, however, exhibits a pattern of intraslab seismicity that substantially deviates from a classical DSZ. Whereas two parallel seismicity planes are present in the updip part of the slab, these abruptly change into a 25-30 km thick, homogeneously seismogenic volume at a depth of ~80-100 km. Seismicity rate and moment release significantly increase in this depth interval. In order to understand which processes evoke this configuration and what distinguishes the Northern Chile subduction zone from more conventional subduction zone settings (e.g. Japan), we performed a detailed seismological investigation of slab seismicity in Northern Chile using data from the IPOC permanent network. We determined >600 moment tensors of intraslab earthquakes, processed and evaluated location uncertainties for 8 years of high-resolution earthquake hypocenter data, and performed statistical analysis of the different seismicity populations.

We observe that earthquakes both in the highly active cluster and the DSZ above exhibit consistently downdip extensive source mechanisms that align

with the dip angle and direction of the slab. This implies strong slab pull, which is also evident from slab steepening outlined by hypocenters towards the downdip termination of the highly active cluster. Moreover, events in the cluster show a very weak aftershock productivity and a high background event rate, which leads to a temporal distribution of seismicity that is close to a purely random process. We find that the position of the highly seismogenic volume spatially coincides with: 1) the disappearance of the velocity contrast between oceanic crust and the underlying mantle in receiver function images, 2) the transition from the``cold nose'' (i.e. the stagnant part) to the hot part of the mantle wedge, as evidenced by seismic attenuation images, and 3) with an

increase of the slab dip angle. Based on these different pieces of evidence, we speculate that high tensile stresses and heat input from above could lead to a sudden burst of kinetically delayed metamorphic reactions there that then enables the observed increased seismicity rates. Since these reactions have overall a negative volume change that leads to slab densification and hence further increases slab pull, the spatial pattern of seismicity we observe could result from a runaway-type process, which would explain its abrupt start and high moment release rates.

Multistage evolution of a Neoproterozoic quartz-gold vein mineralization, Dom Feliciano orogenic belt, Uruguay

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Along the western margin of the Neoproterozoic Dom Feliciano Belt (Uruguay) and its cratonic foreland several vein-type gold occurrences and prospects can be found.

We studied a gold prospect related to quartz veins hosted in dolomitic marble belonging to a Paleoproterozoic platform succession, metamorphosed in amphibolite facies at 550-650°C / 4.5-5 kb. The quartz veins are concentrated in fold hinges and in sheared marble bands, typical of a transpressive regime. Their orientation coincides with the main foliation (N030º) and regional faulting (N110º). Most abundant ore mineral is pyrite, with minor galena, chalcopyrite, sphalerite and accessory enargite, chalcocite and tennantite. Oxidation of sulfides produced free gold besides malachite.

We could establish a clear correlation between micro-textures in quartz observed by CL-microscopy and different fluid inclusion assemblages in order to better constrain the PT-fluid evolution during the main mineralization and subsequent cooling. Primary H2O-CO2-NaCl fluid inclusions with 11-14 wt% salinity and homogenization temperatures (Th) of 330-390°C are found in non-deformed quartz (T0) showing blue CL. Various alteration textures (T1-T4) are marked by quartz with brown and reddish CL, which hosts different types of fluid inclusions: Short trails of pseudo-secondary fluid inclusions containing H2O-CO2-NaCl-CaCl2 (12-13 wt% NaCl + 2-3 wt% CaCl2; Th 180-350°C) are associated with a diffusive network of subgrains (T1), whereas another set of H2O-CO2-NaCl ±CaCl2 fluid inclusions (10-14 wt % NaCl + 0-7 wt% CaCl2; Th 200-350°C) is associated with late-formed grain boundaries (T2). Fluid pathways of fine-grained quartz (T3) are free of fluid inclusions. The latest fluids recorded as fluid inclusions are trapped along healed micro-fractures (T4) and contain low-salinity H2O-NaCl fluids (6-7 wt%; Th 150-220°C).

The mineralizing H2O-CO2 fluid must have been trapped at ca. 500-550°C / 3 kbar, associated to stress relaxation and hydrothermal circulation after the peak of metamorphism. During cooling CO2 may have been lost by carbonation. Besides, the fluid became slightly more saline and enriched in CaCl2 as a result of feldspar alteration. The latter fluids are trapped around the quartz brittle-ductile transition zone at 350-300°C / 2.5-3 kbar (T1) and 300-260°C / 2-2.5 kbar (T2), together with the precipitation of gold. Late fluids of low-salinity may represent the influx of meteoric water, trapped in micro-fractures below ca. 280°C (T4).

The structural data and high fluid trapping temperatures classify the veins as orogenic gold mineralization. The finding of an Ediacaran cooling age of 592.8 ±8.7 Ma for muscovite (closure temperature 425°C) in the veins is consistent with the regional framework of a cratonic foreland, which was strongly reworked during the Neoproterozoic Brasiliano Orogeny.

Probing the Northern Chile megathrust with seismicity – The 2014 M8.1 Iquique earthquake sequence

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We used data from >100 permanent and temporary seismic stations to investigate seismicity patterns related to the 1 April 2014 M8.1 Iquique earthquake in northern Chile. Applying a multistage automatic event location procedure to the seismic data, we detected and located ~19,000 foreshocks, aftershocks and background seismicity for one month preceding and nine month following the mainshock. Foreshocks skirt around the updip limit of the mainshock asperity; aftershocks occur mainly in two belts updip and downdip of it. The updip seismicity primarily locates in a zone of transitional friction on the megathrust and can be explained by preseismic stress loading due to slow-slip processes and afterslip driven by increased Coulomb failure stress (CFS) due to the mainshock and its largest aftershock. Afterslip further south also triggered aftershocks and repeating earthquakes in several E-W striking streaks. We interpret the streaks as markers of surrounding creep that could indicate a change in fault mechanics and may have structural origin, caused by fluid-induced failure along presumed megathrust corrugations. Megathrust aftershocks terminate updip below the seaward frontal prism in the outer continental wedge that probably behaves aseismically under velocity-strengthening conditions. The inner wedge locates further landward overlying the megathrust"s seismogenic zone. Further downdip, aftershocks anticorrelate with the two major afterslip patches resolved geodetically and otherwise correlate with increased CFS, overall indicating heterogeneous frictional behavior. A region of sparse seismicity at ~40-50 km depth is followed by the deepest plate interface aftershocks at ~55-65 km depth, which occur in two clusters of significantly different dip.

Constraining the magmatic-hydrothermal fluid evolution from proximal to distal settings by fluid inclusion and isotopic analyses of ore and gangue minerals and numerical modelling

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Magmatic-hydrothermal systems form a variety of ore deposits at different proximities to upper-crustal hydrous magma chambers, ranging from greisenization in the roof zone of the intrusion, porphyry mineralization at intermediate depths to epithermal vein deposits near the surface. The physical transport processes and chemical precipitation mechanisms vary between deposit types

and are often still debated. For this study, we investigate the fluid evolution from proximal to distal settings at the Pirquitas and Chinchillas Mines in NW Argentina and the Sweet Home Mine, Colorado.

New results from fluid inclusion and isotopic analyses indicate a contribution of magmatic fluids in the formation of the Sn–Ag Pirquitas Mine, even though no direct association to a magmatic intrusion is visible. Therefore, this deposit may represent a rather distal setting. In contrast, the Ag–Pb–Zn Chinchillas Mine is hosted in volcanic extrusive units and is directly associated to an underlying dacite diatreme. In that respect, this deposit is proximal to a volcanic complex, but due to its shallow emplacement is distal to an inferred magmatic intrusion at depth. The Ag–polymetallic Sweet Home Mine (currently mined for gemmy rhodochrosite) is related to an assumed hidden Mo porphyry, but may be located more proximal to a magmatic intrusion as compared to the other deposits.

Performing fluid inclusion analysis, Raman spectroscopy, noble gas isotopic compositions and LA-ICPMS measurements as well as the analysis of stable (H, O, S) and radiogenic (Pb, Sr) isotopic compositions, we aim to reconstruct the evolution and P-T-x properties of the ore-forming fluids in the respective ore deposits. As all studied deposits are characterized by a distinct sulfide mineralization stage, we also investigate whether this stage has formed by mixing of magmatic fluids with variable amounts of externally derived fluids. Furthermore, numerical modelling of the transition from a porphyry to an epithermal environment, considering country rock permeability, fluid pressure distribution, fluid temperatures, and varying locations of the magmatic plume, is used to build a quantitative model for the formation of these types of epithermal deposits.

Analysis of diversification histories in extinct carnivorous marsupials (Sparassodonta, Metatheria) using a Bayesian framework

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South America was isolated during a great time of the Cenozoic, allowing an endemic terrestrial biota to evolve. Within mammals, the carnivore guild was occupied by the Sparassodonta from the Palaeocene to the Pliocene. Moreover, from the late Miocene - Pliocene, carnivorous placentals (Carnivora) began to colonize the continent from North America, after the formation of the Isthmus of Panama. Given that, some authors proposed the „competitive displacement" hypothesis justifying the extinction of sparassodonts by the arrival of carnivorous placentals, while others proposed an „opportunistic replacement". We compiled a data set of fossil occurrences for Sparassodonta and their potential competitors in South America (six families of Carnivora) collected from the literature and museums databases. All analyses were done with a Bayesian framework in the PyRate software. First, we estimated the preservation rate and the times and rates of speciation and extinction through a reversible jump Markov Chain Monte Carlo (RJMCMC). We ran 20000000 RJMCMC iterations and sampled once every 5000 to obtain posterior estimates of the parameters. Additionally we tested if the diversification dynamics of Sparassodonta may be linked with changes in body mass (using a Covar birth–death model) and in global temperature (using a birth–death model with time-varying rates). Information of body mass and temperature were obtained from the literature. Finally we assessed the effect of competition on the diversification of Sparassodonta with a Multiple Clade Diversity Dependence model. Our results show temporal changes in both speciation and extinction rates for Sparassodonta, supporting the idea that the demise of a clade is controlled by the two factors. Regarding body size there is a trend where the larger body mass in Sparassodonta appears later in their evolutionary history. Although the changes in body mass are not related to the speciation rate, they are related to the extinction rate (i.e., as the size increased, the extinction rate decreased). No significant correlations emerged between the global temperature curve and changes in diversification rates. Finally, clade competition did not affect the diversification dynamics of Sparassodonta; speciation rate fell before the dispersion of Carnivora in South America. In conclusion, these new techniques can improve our knowledge of the evolution of the taxa but more studies are required to elucidate the demise of Sparassodonta.

The Iglesias Complex in the Merida Andes Venezuela: A record of Cambrian-Silurian continental arc and Permo-Triassic Pangea amalgamation in western Gondwana

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The metamorphic basement of the Mérida Andes in western Venezuela is constituted of Early Paleozoic metasedimentary rocks, orthogneiss, and amphibolite of the Iglesias Complex. In this work, U-Pb-Hf-O data in zircon, Rb-Sr geochronology, and Hf-Nd isotope systematics are combined to constrain the magmatic and metamorphic history of these rocks. The results are framed in the

tectonic settings proposed for Northwestern Gondwana and correlated with equivalent Paleozoic rocks in other peri-Gondwanan crustal fragments. Paragneiss and schist derived from pelitic-psammitic and volcaniclastic protoliths, locally alternating with amphibolite lenses suggesting a volcanic or volcaniclastic origin. Detrital zircon ages suggest that sedimentation of paragneiss protoliths spans from ~520 Ma to ~490 Ma, whereas chemical and isotopic signatures are suggestive of sedimentation in a back-arc setting. Biotite-garnet orthogneiss protoliths intruded Cambrian paragneiss at ~487 Ma, during crustal thickening and Barrovian metamorphism (M1), reaching anatexis at ~467 Ma. Gneissic rocks were later intruded by mafic to intermediate lower-crust and mantle-derived magmas (now hornblende orthogneiss and amphibolite) in a back-arc setting at ~460-455 Ma. Later, a compressional setting led to high-grade metamorphism (M2) at ~450 Ma, followed by decompression melting at ~430-420 Ma (M3). Finally, an upper greenschist-facies overprint in the metamorphic complex occurred at ~250 Ma (M4). The Early Paleozoic tectonothermal events are related to alternating cycles of advance and retreat of the subduction slab in an active continental arc, broadly recognized as the Famatinian orogeny, which formed along the proto-Andean margin of Western Gondwana. The Permo-Triassic metamorphism is related to the final amalgamation of crustal blocks to form the Pangea supercontinent, probably driven by late tectonic effects or diachronic formation of the Ouachita-Marathon-Sonora suture between Gondwana and Laurentia. The Iglesias Complex has several similarities to rocks of the same age in other crustal fragments adjacent to Northwestern Gondwana, such as the Santander Massif in Colombia, and the Acatlán Complex and the Maya Block in southern Mexico-Central America. However, the pre-Ordovician history of the Maya Block is different because this basement hosts inliers of Stenian-Tonian crustal rocks, as well as metasedimentary rocks associated with the Rodinia Supercontinent break-up (~600-580 Ma).

The Paleoproterozoic Minas Orogen, São Francisco Craton reviewed: insights into an evolving accretionary-collision orogenic system and global implications

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The Paleoproterozoic Minas orogen played a fundamental role in the assembly of the São Francisco-Congo paleocontinent at ca. 2.0 Ga ago. This long-lived accretionary-collision system generated the Mineiro composite belt (2.47-2.10 Ga), as well as the adjoining cordilleran Mantiqueira (2.20-2.00 Ga) and juvenile Juiz de Fora (2.44-2.08 Ga) complexes both exhibiting Neoproterozoic reworking. Disperse basement complexes within the surrounding Neoproterozoic belts that widely overlap in time the Minas orogeny suggests its larger primary extent, forming the paleocontinent. Coeval orogenic units similarly occur in the northeastern portion of the São Francisco craton (Salvador-Itabuna-Curaçá belt) and in the African counterpart such as the Eburnean orogeny and the Kimezian basement of the West Congo belt. The evolution of the Mineiro belt - the best studied orogenic domain - comprises four distinct groups of subduction-related granitoids generated between 2.47 and 2.10 Ga within a Siderian-Rhyacian ocean, as inferred by whole rock Nd-Sr and coupled zircon Hf isotopic constraints. The associated volcano-sedimentary successions deposited in island arc settings during the same age interval of the granitoids. They mainly derived from Paleoproterozoic sources, as indicated by zircon U-Pb provenance studies and zircon Hf constraints. From a geodynamic point of view, the Minas orogeny resumed apart from the primeval Archean landmass, shortly following GOE and/or accompanying deposition of the Lake-Superior type strata (the Minas Supergroup), including banded iron formation, in the passive basin. The orogenic history evolved, respectively as an intra-oceanic arc system and a continental margin basin that interacted and collided during the transition between the Rhyacian and Orosirian periods (ca. 2.10-2.05 Ga), eventually causing widespread deformation and metamorphism over the foreland and reactivating structures formed during an Archean dome-and keel formation event. The global scenario envisages potential links between the Congo-São Francisco palaeocontinent and Columbia Supercontinent, given by paleogeographic correlation of Rhyacian-Orosirian aged crustal segments on nearly all continents.

Autogenic controls on the distribution of sediments and palaeosols in ancient distributive fluvial systems (Bauru basin, Brazil)

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Palaeosols are ubiquitous features that appear interbedded with deposits in the stratigraphic record of distributive fluvial systems (DFS). They correspond to open systems that are highly sensitive to record changes in topography, climate, groundwater level and periods of no sedimentation, which are the main controlling mechanisms in the stratigraphic architecture of DFS. This work applies a sediments-palaeosol approach to reconstruct a refined stratigraphic framework of an ancient DFS in the Serra da Galga Formation (Upper Cretaceous, Bauru Basin, Brazil) to further uncover the mechanisms controlling sedimentation and associated pedogenesis. A

total of 12 sedimentary facies, 5 architectural elements and 4 pedotypes were observed from proximal to distal zones of the studied DFS. The proximal zone showed an arrangement of large-scale channel deposits separated by well-drained Inceptisols. The intermediate zone revealed a more complex framework of large-scale channels coexisting with interchannel and small-scale ribbon channel deposits. In this part of the system, Inceptisols overlay the channelised deposits, Entisols develop over proximal interchannel deposits and gleyed Vertisols occur over distal interchannel deposits formed in lowlands on the alluvial surface. The intermediate-distal zone displays isolated small-scale ribbon channels interbedded with interchannel deposits, which are overlaid by poorly-drained gleyed Inceptisols. From channel to interchannel deposits, pedotypes appear to be distributed in a palaeocatena controlled by the topography and sedimentation rate of the ancient DFS. Avulsing channels in the elevated channel ridge permit the development of Inceptisols. Entisols are formed in the proximal interchannel areas that are frequently submitted to episodic floods. On distal lowlands of the interchannel area, Vertisols appear and register some grade of groundwater influence. From apex to toe, the DFS showed a larger-scale palaeocatena pattern where well-drained Inceptisols developed over topographically elevated channel ridges in the proximal zone, passing downstream to gleyed Vertisols in the distal floodplain areas of the intermediate zone to ultimately form poorly-drained Inceptisols at the intermediate-distal zone. This large-scale palaeocatena indicates that the proximity to the groundwater level acts as the key mechanism controlling the distribution of palaeosols. In conclusion, the sediments-palaeosol approach not only allowed a more refined tridimensional DFS model, but also brought access to the major factors governing the architecture of the system. From proximal to intermediate zones, topography acted as the dominant controller on pedogenesis. Additionally, the groundwater level showed increasing control over pedogenesis of lowlands in a down-system direction, forming a superimposed larger-scale palaeocatena.

Paleoclimate reconstructions from fluvial sedimentary deposits in an intermontane basin in the southern Central Andes - A case study from the Quebrada del Toro, NW Argentina

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Long profiles of alluvial channels are sensitive to the amount of water discharge (Qw) and sediment supply (Qs). Both are in turn a function of local climatic and tectonic conditions. As such, changes in the prevailing environmental (tectonic, climatic) conditions will result in channel slope adjustments, either by sediment deposition or by incision into previously deposited sediments. Fluvial terraces or abandoned alluvial fans can therefore be valuable archives of past environmental conditions, as they preserve ancient river elevation profiles of distinct times in the past.

In NW Argentina, little is known about Pleistocene environmental conditions. This is due to the limited availability of paleoclimatic records, such as information derived from lake cores or stable isotope data from speleothems. However, many intermontane basins within the Eastern Cordillera of the Southern Central Andes of NW Argentina are characterized by multiple generations of fluvial-fill terraces and alluvial fans, which date back several tens to hundreds of thousands of years. Here we show that these sedimentary units provide an opportunity to extract information about paleo- environmental conditions.

By combining several geochronologic techniques, we have reconstructed the chronology of a >200-m-thick fluvial-fill terrace sequence within the Quebrada del Toro that experienced alternating episodes of aggradation and incision. The uppermost terrace was dated to ca. 500 kyr. Subsequent terraces appear to have formed following a cyclicity of ca. 100 kyr. From those terrace sediments, we reconstructed Qs at times of terrace aggradation based on cosmogenic 10Be concentrations. The analyses reveal that paleo Qs over the last ~500 kyr has varied at most by a factor of 4, but overall has been relatively constant. As the slope of a river channel (and likewise, a terrace surface) is a function of incoming Qs and Qw, the information on terrace slope and paleo Qs allowed us to reconstruct paleo Qw for the times represented by the terrace surfaces. We find that river discharge during the onset of river incision was 10 to 80% higher than today. Our results are in line with previous quantitative estimates of paleo-precipitation changes in the Central Andes, but have the advantage of dating further back in time. Moreover, the widespread occurrence of fluvial fill terraces and alluvial fans throughout the Central Andes offers the opportunity to reconstruct paleo-water discharge with high spatial resolution, offering a unique perspective regarding the impact of paleoclimate changes on the sediment-routing system through space and time.

Palaeoenvironmental changes over the last millennia in the subtropical forests of Northwest Argentina inferred from fossil pollen records.

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Recent research has provided evidence that many tropical and subtropical mountain plant species of South America are shifting their ranges upslope as a response to global warming. Some predictive models ensure that this trend will continue in the near future. Consequently, documenting the response of subtropical forests to present and past environmental changes is very useful in developing and validating vegetation models. Therefore, to have a greater degree of accuracy of these models, it is necessary to dispose of long-term studies. Currently, long-term specific data are scarce for the majority of subtropical tree species in South America. In order to contribute information about how the subtropical trees (e.g. Alnus acuminata, Polypepis australis, Podocarpus parlatorei, among others) of northwest Argentina responded to climate variability in the past, we have conducted a high-resolution analysis of a fossil pollen sequence in order to interpret the vegetation dynamics for the last millennium. We aimed to investigate the following topics: 1- Assess if the temperature is the unique parameter that induces vertical migration of the vegetation belts, 2- Distinguish vegetation responses to regional events (precipitation variability linked to the activity of South American Monsoon System). To achieve this, three sediment cores of different deep were extracted in Laguna Comedero (24º 06“S - 65º 29“ W, 2035 m a.s.l.). Here we present the results of the reconstruction of vegetation based on pollen analysis that spans the last 1200 yr BP. The most important change in vegetation composition was observed ca. 1000 yr BP, when Poaceae pollen dominated indicating the expansion of the grassland by drier conditions or anthropic disturbance like deforestation. Later Alnus pollen appears as dominant until the present. Changes percentages in fossil pollen content, like increase in grasses, herbs and shrubs, could be related with a diverse degree of landscape handling, and/or dries periods, while increases of arboreal pollen can be attributed to more humid conditions (Alnus forest is related with up to 1000 mm/yr rainfalls, and the montane grassland with 600 mm/yr or less). Although, increases of the Alnus forest could be relatively more humid periods; this could also reflect moments of colonization in areas with strong environment disturbance (i.e. slipping). This evidence suggests that precipitation also could be a driver of the Alnus forest dynamics.

Seismic imaging of the source region of great megathrust earthquakes offshore Chile: an overview of recent results

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The slip distribution during any particular great suduction zone earthquake depends on the rate-state complexity of friction, the rate of strain accumulation, the past history of earthquake activity, and the geology along and adjacent to the plate boundary. To try to better understand how geologic structure affects the distribution of slip, we have conducted three marine expeditions in the past several years to image the source regions of recent earthquakes with M>8 offshore Chile. Although each experiment had a different operational strategy and spatial/temporal footprint, they had the common objective of providing constraints on the geologic structure of the earthquake source region. During ChilePEPPER (Project Exploring Prism Post-Earthquake Response) in 2012-2013, we acquired a grid of high-resolution multichannel seismic (MCS) reflection profiles and deployed a dense network of ocean bottom seismometers and absolute pressure sensors with integrated fluid flow meters updip from the patch of greatest slip during the 2010 M8.8 Maule earthquake. The initial goal was to determine how the outer accretionary wedge responded to ~15 m of slip deeper in the subduction zone. Based on several lines of evidence, we conclude that the outer wedge along this portion of the margin may have slipped to the trench and that an abrupt deepening of the plate boundary at the deformation front may have arrested northward propagation of rupture (comparable to a step-over in a strike-slip fault). During PICTURES (Pisagua/Iquique Crustal Tomography to Understand the Region of the Earthquake Source) in 2016, 70 ocean bottom and 50 onshore sites were deployed to record the large-volume airgun array of the R/V Marcus Langseth as it acquired 4400 km of seismic reflection/refraction lines in a grid to image the source region of the 2014 earthquake offshore northern Chile. The goal was to obtain a 3D Vp tomographic model, with additional constraints on tectonics from the MCS data, to understand the geologic reasons for a remarkable correlation between the gravity field and seismic activity leading up to, during and following the 2014 M8.2 Pisagua/Iquique earthquake. One preliminary conclusion from PICTURES is that southward propagation of slip during this earthquake sequence was arrested by a significant change in upper plate crustal structure. During CEVICHE in 2017, a 1500-km long section of the margin was imaged in 2D using the Langseth source and 15-km long streamer (~5000 km of MCS data in all). Shots were also recorded onshore to provide constraints on lower crustal velocity structure. The CEVICHE footprint covered the 2015 M8.3 Illapel and 2010 M8.8 Maule earthquake

source regions as well as the northern half of the 1960 M9.5. Here subduction of nearly the entire trench sediment package at the deformation front is observed along most of the region, shielding the plate boundary from topography on the subducted plate. Some of the subducted sediment may be underplated at greater depth, and efforts to image beneath the continental shelf are ongoing. Taken together the results indicate the importance of both upper and lower plate structures in controlling the evolution of the plate boundary and its integrated response to plate tectonics.

Testing long-term controls of sedimentary basin architecture in the broken foreland II – Modelling the spatial variability of the strata

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Spatial variability of the strata and associated depositional geometries in a basin determine the regional distribution of possible reservoir and seal units. While the distribution of facies can be predicted to some extent by sequence stratigraphy theories, these models offer a conceptual framework to extrapolate facies distribution at a regional scale, albeit as soon as the scale of observation increases, these models are no longer able to represent the geological complexity and the facies variability in a realistic and reliable way.

In this project we will focus on the Yacoraite Formation (Salta Group) in the Tres-Cruces sub-basin (Salta Basin, North Western Argentina). The outstanding quality of the outcrops in this location and the stratigraphic succession of the Salta Group offer an extraordinary laboratory to study spatial facies variability in a post-rift basin. We will study and attempt to interpret the role of extrinsic and autocyclic controls (tectonics, climate, sediment supply, inherited topography) and try to better define and constrain the rules that determining the interplay of clastic and carbonate sedimentation. The work will involve detailed characterization of outcrop analogues to study the spatial variability and 3D facies architecture, this data will serve as a basis for 3D numerical and forward modelling (PETREL and DIONISOS) to test and simulate a range of sedimentary processes and scenarios, in order to investigate how tectonics and climatic conditions are interconnected with basin intrinsic factors. Thus, this project will contribute to characterizing and quantifying 3D facies distribution in outcrops, analogues for sub-surface exploration, at basin and reservoir scales and to evaluate the controls over the vertical and lateral stratigraphic architecture.

Fluid inclusion and stable isotope geochemistry of rare-metal pegmatites, Sierra Grande de San Luis, Argentina

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In the Sierra Grande de San Luis, Nb-Ta-enriched pegmatites (398-411 Ma) outcrop in the eastern Conlara Metamorphic Complex, while Sn-enriched pegmatites (404-444 Ma, Sosa et al., 2002) outcrop in the more western Pringles Metamorphic Complex. The pegmatitic bodies are concordantly emplaced in fine-grained quartz-mica schist. The pegmatites represent the residual fluids of S-type syn-tectonic, meta- to peraluminous leucogranites of Famatinian age (Ortiz Suárez and Sosa, 1991; Galliski et al., 2019). The Nb-Ta-enriched pegmatites show a more complex mineralogy and contain beryl, spodumene and amblygonite, suggesting a higher internal fractionation, whereas the Sn-pegmatites principally contain Ab-Qtz (albite-type).

Aqueous-carbonic inclusions are typically trapped in cassiterite, plagioclase, beryl, apatite, tourmaline and quartz, whereas aqueous inclusions are found in columbite-tantalite, garnet, staurolite, quartz and in some cases also in plagioclase. Salinities in aqueous inclusions are usually low. The non-aqueous phase contains CO2, N2, CH4 and sometimes traces of H2S.

The δ13C values of CH4 in cassiterite, plagioclase, quartz and tourmaline vary between –45 and -37 o/oo VPDB, indicating organic origin. The CO2 from the Sn-pegmatites (all minerals) shows lower δ13C values (mainly –17 to -8 o/oo PDB) compared to the Nb-Ta-pegmatites (mainly –12 to 0 o/oo PDB), suggesting more extensive assimilation of organic material and therewith lowering of the oxygen fugacity in the Sn-bearing fluids. The δ15N values of N2 range between 0 and +4 o/oo for fluids in cassiterite and quartz from the Sn-pegmatite and slightly higher (ca. +2 to +8 o/oo) for quartz from the Nb-Ta-pegmatite, suggesting the mixing of magmatic and organogenic nitrogen.

We can distinguish between fluids with a more magmatic signature which correlate with Nb-Ta-pegmatite mineralization, and fluids which changed composition due to interaction with the surrounding metasediments. Stable isotope signatures suggest that the pegmatitic fluids assimilated organic material from the metasedimentary country rocks particularly in the Pringles Metamorphic Complex. This agrees with the idea that the original magmatic fluids were regionally homogeneous, and that the pegmatite emplacement took place during or shortly after the peak of metamorphism during the Ordovician. Tin may have been leached from the Pringles Sn-enriched sediments and crystallized as cassiterite at increasing fO2 and/or pH conditions at cooler deposition

sites or as a result of interaction with meteoric water.

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Unveiling giant tsunamigenic earthquakes along the hyperarid Atacama Desert in the major Northern Chile Seismic Gap at multimillennial timescales

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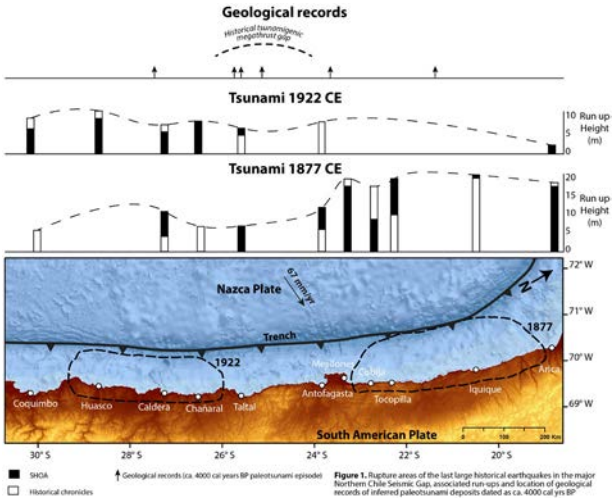
The subduction margin of the Nazca plate beneath the South American plate along Northern Chile is considered to be among the major seismic gap regions worldwide encompassing more than 1000 km between Arica (18.47ºS) and Huasco (28.47ºS). Along this major converging tectonic margin, the last large tsunamigenic earthquakes were the Mw~8.8 1877 CE and the Mw~8.5 1922 CE events, whose rupture areas occurred along its northern and southern segments, respectively. Only limited ruptures have occurred in the mysterious segment located in the middle and no large historical tsunamis have been generated in front of the Taltal region (25.4ºS).



In spite of the scarcity of data, we used a range of multidisciplinary and multiproxy approaches in an attempt to identify paleotsunami and paleoseismological evidences. From the assessment of geoarchaeological records, submarine features and uplifted littoral sediments -well preserved in carefully identified sheltered environments- along the hyperarid coasts of the Atacama Desert, we identified paleotsunamis and associated paleoearthquakes. Evidence from this research points towards large to giant transpacific tsunamis occurring close to 1454 +/-36 CE and to 1297 +/-23 CE. More importantly, a recent discovery revealed growing evidence for a Mw~9.5 megathrust earthquake and tsunami that caused a dramatic social disruption along this vast extremely arid coastal region around 4000 cal years BP (Figure 1), suggesting the capability of this major seismic gap to produce super-earthquakes and tsunamis at multimillennial timescales with significant human consequences.

The Paleozoic Claromecó Basin (Argentina): 3D lithospheric scale density model.

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The Paleozoic Claromecó basin is located to the southeast of Buenos Aires Province between 37°- 39° S and 61°- 63° W and has been subject of multiple geological and geophysical studies. Different hypotheses and mechanisms have been proposed for the genesis of this basin, as well as for the deformation of the Australes Ranges.

The principal goal of this work is to contribute to a better knowledge of the Claromecó basin evolution on the basis of the development of a lithospheric scale 3D gravity forward model.

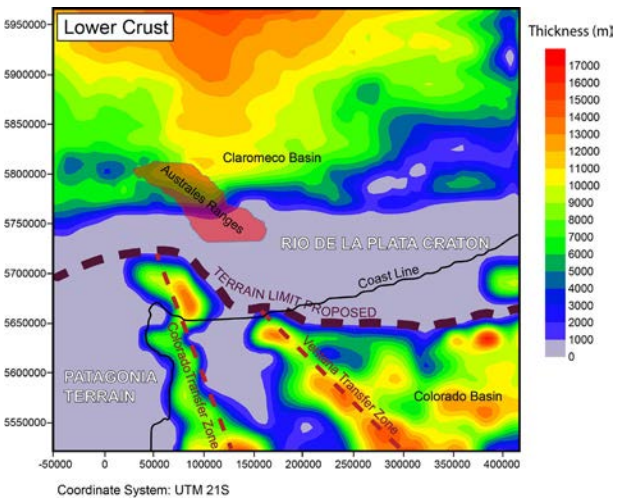
For the model construction, we integrated several data, such us geological information, a global gravity model (EIGEN 6c4), well data (Lesta and Sylwan, 2005), seismic tomographies, and pre-existing 3D models of the Colorado basin (Autin et al., 2016).

We used the software IGMAS+ to develop our model and fit the measured gravity, by modifying the free parameters: the lower and upper crust top layers.

Concerning densities, we parameterized the lithologies by assigning constant densities for each unit. For the Colorado basin area, we selected values consistent with Autin et al. (2016) and used the bulk density values published for the Claromecó basin sediments.

Our model allows to gain insight into the Moho depth, the variations of the thickness of the sedimentary infill and the upper and lower crust, in the studied area. We also propose a tentative location of the southern limit of the Rio de la Plata craton.

Our results contribute to the understanding of the geodynamic evolution of Claromecó basin and of the tectonic processes which affected the southwestern margin of Gondwana during Paleozoic times.



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Multi-Array Back-Projection: Rupture complexities due to asperities along-dip barriers during the 2007 Mw 7.7 Tocopilla earthquake

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Since the 26 December 2004 Mw 9.1 Sumatra-Andaman earthquake, back-projection imaging of earthquakes based on high-frequency emissions has become a complementary method to Finite Source Inversions, providing information related to the rupture area, rupture velocity, and energy distribution in time and space without any prior fault geometry knowledge requirements. Its advantages lie on the possibility to constrain a rupture pattern as soon the data is available by considering the coherence of multiples signals arriving at an array of seismometers, which in effect, contribute to defining a complete tool for spatio-temporal monitoring of global seismic sources and for earthquake hazard evaluations at regional and teleseismic distances. Further developments have allowed its extension from a time-domain approach to frequency-domain methods while multiple applications have, for example, characterized major subduction zone earthquakes, aftershocks detection, complex ruptures and intermediate-depth earthquakes among others. However, despite its fast development, the dependency on large arrays has severely limited the azimuthal coverage of many events. Even when multiples seismic arrays have been considered the impact of their spatial disposition has not been taken into account in-depth exacerbating potential artifacts on the solution.

Here, we have extended the traditional time-domain back-projection with a multi-array approach, which harnesses regionally distributed seismic stations in addition to the large-scale arrays usually employed to widen azimuthal coverage. We have also included the analysis of multiple seismic phases in the back-projection algorithm to reduce source effects. Our analysis provides a detailed description of high-frequency ruptures and is suitable to be standardized and automated for near-real-time applications, which is tested here with the 14 November 2007 Mw 7.7 Tocopilla earthquake located in the southern edge of the northern Chile seismic gap and characterized with a slip distribution along the deeper part of the seismogenic zone. We have calibrated the travel time corrections with some of the large aftershocks of this event in order to be able to interpret the rupture history within their context. We found the high-frequency rupture emissions (0.5-2.0 Hz) have encircled the dominant asperities along the fault area with the cumulative energy being emitted up-dip of the coseismic slip area and well associated with the along-dip segmentation acting as a barrier in this region. The method has offered an improvement in terms of resolution and data availability and its application is directly extended to different earthquakes and rupture behaviors including the analysis of complex ruptures and supershear rupture events.

Instrumental monitoring of shallow slip events on active faults reveals the ability of velocity weakening behavior at shallow crustal levels

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Mechanical models to describe the slip behavior and displacement accumulation pattern of shallow slip on major fault zones are contradictory. Recent observations suggest that, despite low confining pressure and phyllosilicate rich fault gouges at shallow crustal levels, faults can exhibit velocity weakening behavior all the way to the surface. These recent observations necessitate a reinvestigation of the asperity and seismogenic zone model. The observation of triggered shallow slip events on segments of the Atacama Fault System (AFS) in N-Chile (Victor et al. 2018) monitored with the IPOC Creepemter Array demonstrated that the AFS exhibits the ability to slip seismically at shallow depth.

Our follow-up study now uses the IPOC Creepmeter Array to further investigate these slip events both from their instrumentally observed properties as well as their fault zone properties in the field, to unravel the spectrum of fault slip modes.

The available instrumental dataset covers a time span of 8 years at 11 monitoring sites and comprises both triggered shallow slip events and creep signals. The recorded shallow slip events range from m to mm scale. Slip velocities for these events range between 10-11 -10-5 m/sec and slip durations up to 300 sec, therefore covering a spectrum from creep events to slow earthquakes.

Further decomposing the time series recorded at the creepmeter stations we are able to differentiate between slow creeping fault segments and others which are accumulating displacement solely by triggered shallow slip events. As a result of this analysis we can state that only one of the fault segments preferentially creeps at shallow depth, whereas the others preferentially accumulate permanent displacement by accumulation of slow slip events. Additionally in the decomposed time series of one fault we see a transient creep signal of 1,5 years after an unusual rainfall event, which can be clearly discriminated from the otherwise not creeping signal.

Comparing these observations with the fault gouge thickness at the creepmeter sites, we find a strong correlation of segments exhibiting 10 cm thick fault gouge at the monitoring site and creeping fault behavior. By contrast fault segments, accumulating displacement only via triggered shallow slip events, do not have a fault gouge developed. Instead these fault contacts are developed in a strongly fragmented basement/basement contact zone or show a submillimeter thin sharp contact in alluvial fan sediment. These first results demonstrate that AFS fault segments at shallow depth exhibit a spectrum of fault slip modes ranging from creep to slow earthquakes that is closely linked to fault zone properties, therefore corroborating the ability of seismic rupture potential at shallow crustal levels.

Carbonate reservoirs of Brazilian pre-salt

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The Brazilian pre-salt oil filed province was discovered in 2006 and currently produces roughly 1.5 million barrels of oil per day. The province comprises a lacustrine rift and Sag deposits developed under transgression by the breakup of the Gondwana supercontinent. The main reservoirs are distributed in the Santos and Campos Basins, located at the east coast of Brazil.

The deposits of the rift phase were settled during the late Barremian-Early Aptian ages, and are mainly described as shell condensed deposits (coquinas) interbedded with shales under a lacustrine system. The main carbonate facies are described as rudstones and floatstones constituted by bivalve and gastropod shells and their fragments. The rudstones are the dominant reservoir facies, where the sorting and diagenetic process, as dissolution of shells, enhance the pore system and the connectivity.

The deposits of Sag succession were settled during the Aptian age, they are constituted by continental carbonate and non-carbonate rocks associated with coeval basalts. The depositional environment involves a low–temperature hydrothermal and evaporitic conditions, with strong influence of ascending Ca-Mg-Si rich fluids that migrate through faults, emerging in a subaerial and lacustrine spring.

The predominant facies of Sag deposits are: shrub-like limestones, bedded travertines, laminated microbial boundstones, Mg-rich silicate argillites, as well as high to low energy reworked facies. The deposits were heterogeneously modified by early diagenesis, represented by intense replacement/cementation by dolomite and quartz and a varied degree of dissolution, in some cases related to karst features.

As a consequence of geological heterogeneity, these rocks present a wide range of types and sizes of porosity at many scales, which makes it difficult to predict the permeability values or the flow conditions of the reservoir. Thus, the understanding of the geological and petrophysical heterogeneities is critical for better the classification methods that honor the reservoir static properties.

Reconstructing past climatic changes using lacustrine sediments from Laguna Comedero, NW Argentina

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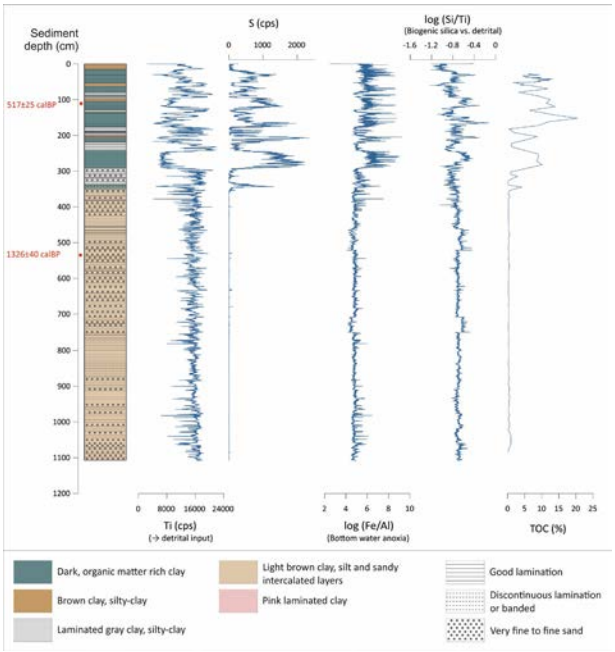
The present rainfall pattern in the eastern flank of the Central Andes of NW Argentina results from the interplay between topography and moisture transport during the wet season, mainly controlled by the dynamics of the South American Monsoon System (SAMS).This region is sensitive to shifts in the SAMS, as well as the superposition of other large-scale phenomena (e.g., El Niño Southern Oscillation, Pacific Decadal Oscillation) and therefore constitutes a key region for obtaining realistic regional reconstructions of past climate variability. In this sense, the timing and extent of precipitation changes prior to the instrumental period in this area are still largely unknown, preventing a better understanding of the long-term drivers of the SAMS and their effects over the Central Andes of NW Argentina. Laguna Comedero is a highly variable shallow lake located in the subtropical forest of the Yungas in the foothill of the Argentine Eastern Cordillera (24º 06“ 54.7“ S - 65º 29“ 7.2“ W, 2,035 m asl). A multi-proxy analysis of an 11 m-long sediment record

of this lake system provides new data for reconstructing the regional late Holocene climate history in this region of South America.



Our results reveal important changes in sedimentation, from detrital brown layers in the lower part of the core to an alternation of gray clastic and black organic-rich intervals with abundant plant debris in the upper 3.5 m (Fig. 1). Below this sediment depth TOC and S values are low, in combination with high values of elements indicative of detrital input (e.g. Ti), revealing no variation of detrital sediments and low ammounts of organic matter. However, TOC, C/N and S values stongly increase above 3.5 m. TOC values in the upper 3.5 m ranges from 0.1 to 20.5%, while organic C/N atomic ratio reaches values up to 17, suggesting a substantial contribution of terrestrial organic matter in some layers. These intervals also show low Ti and high S and Fe/Al values that toghether with the presence of Pyrite, indicate periods of reducing conditions at the lake bottom. Changes recorded in Laguna Comedero sediments reveal that the deposition in the lake varied strongly in the upper 3.5 m of the sediment record indicating an important environmental change at the beginning of the last millennium (ca. AD 1,092). Further analysis needs to be done and a detailed chronological framework is still required to reveal the link between these sediment record changes and the past climate and environmental fluctuations for this region. Thus, future results will provide important insights on the past SAMS activity in the eastern slope of the southern Central Andes.

Isotopic (Nd-Sr-Pb) signature of the diamictitic iron formations from the Neoproterozoic Macaúbas group, Araçuaí orogen, SE Brazil

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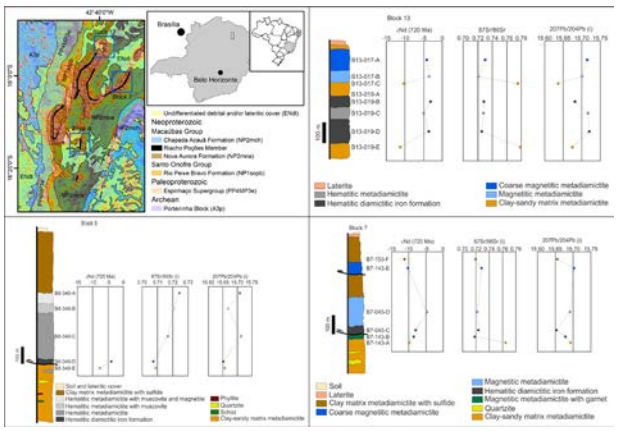
Diamictitic iron formations (DIF) from the Neoproterozoic Macaúbas Group (Nova Aurora Formation, Riacho Poções Member) are potentially associated with a Cryogenian glaciation not yet precisely dated in the region. The studied DIF deposits, hosting large volume of iron oxides, formed during a rifting stage of the Macaúbas basin. They are classified as hematite-type DIF and magnetite-type DIF deposits, according to the variable contents of the main iron oxides found in the metadiamictite matrix. The hematite-type DIF deposits mostly include mylonitic, matrix-supported metadiamictites of grey color, generally containing 5 to 60% (all % refer to vol% as modal estimates) of total iron oxide in matrix. Fine-grained (< 0.1 mm to 0.55 mm) hematite occurs disseminated in the foliated matrix and concentrated in deformation bands. Hematite-type DIF also includes quartz (25-46%), muscovite (8-28%) and carbonate (1-10%), as well as epidote and biotite that locally can reach up to 5% and 8%, respectively. Other accessory minerals are tourmaline (< 2%) and apatite (< 2%). Large (up to 1 mm) magnetite porphyroblasts (< 3%) are euhedral crystals disseminated in matrix or deformed in mylonitic bands. The dark grey magnetite DIF is generally richer in Fe than the hematite DIF, but less abundant, mostly occurring in highly deformed shear zones that show increase in magnetite content in relation to hematite (< 10% to absent). Magnetite reaches up to 40% of the matrix volume, being usually porphyroblastic, and euhedral to subhedral. Quartz (30-75%), muscovite (5-25%) and carbonate (3-15%) are the other main components of matrix. Chlorite and biotite can be present up to 30% and 20%, respectively. Magnetite DIF with abundant chlorite and biotite shows green color and commonly exhibit garnet porphyroblasts. Despite the regional deformation and mylonitization in shear zones, magnetite crystals tend to keep euhedral habitus with no evident deformation features. To establish the sedimentary provenance of the metadiamictites and the source of iron, isotope analyzes were carried out on drill core samples from three DIF deposits named blocks 7, 8 and 13. Preliminary results from whole-rock samples yielded εNd values from -3.2 to -11.3, 87Sr/86Sr(i) from 0.7073 to 0.7650, and 207Pb/204Pb(i) from 15.6 to 15.7. In the three sampled localities, a shift from more negative to less negative εNd values can be observed from the Fe-poor to Fe-rich metadiamictites (-7.6 to -3.9; -11.2 to -3.6; -9.9 to -8.6). Samples from blocks 7 and 13 reveal a pronounced shift in the 87Sr/86Sr(i) from Fe-poor to Fe-rich units (0.7650 to 0.7188, and 0.7626 to 0.7229), while the 87Sr/86Sr(i) shows, in block 8, a smoother trend towards more radiogenic values from the base to the top of the sequence.

Values of 207Pb/204Pb(i) are rather uniform, showing no irregular scatter along sections and no clear difference between them.



Strontium isotope dating of evaporites and the breakup of the Gulf of Mexico and Proto-Caribbean seaways

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The recently installed Nu-Instruments® Thermal Ionization Mass Spectrometer (Nu-TIMS®) with zoom optics and fixed Faraday cups at CICESE, Ensenada, México, is capable to analyze isotope ratios in dynamic mode (peak jumping) with perfect cup alignment, yielding precise and accurate data. Strontium isotope composition of seawater and most brackish waters are uniform for a given time but varied during geologic history of the Earth. The Strontium evolution curve can be used to obtain stratigraphic ages from suitable salt samples deposited in marine environment (e.g. [1], [2]).

New and existing Strontium isotope data are presented for seven areas of evaporite deposition within western equatorial Pangea (middle America). The data show that halite was deposited on the proximal margins of the northern and southern Gulf of Mexico (GoM) at about 169-170 Ma (Bajocian), whereas a thick anhydrite was deposited in Trinidad at 166 Ma (Callovian). The data constrain numerous problems such as: (1) the Couva Evaporite in Trinidad pertains to rifting rather than to Cretaceous carbonate platform deposition; (2) the salt drilled in Mata Espino-101B (Veracruz Basin) is Bajocian (halite) or Bathonian (gypsum), but the depositional site was probably beneath the Sierra Madre Oriental thrustbelt west of Veracruz Basin before that area was part of the GoM; (3) a 3-9 m.y. hiatus appears to exist in proximal areas around the GoM, above salt and below Late Oxfordian marine sequences (Norphlet „window"), caused by either marginal uplift (thermal?) or by the water level failing to fill the basin to paleo-sea level again (probably producing an offlapping architecture); (4) based on detrital zircon dating, salt deposition in parts of Mexico, at least, appears to have proceeded from continental deposition immediately, but this looks less likely for the US sector; (5) we strongly suspect, but cannot yet prove, that salt youngs basinward in the GoM and is Callovian-Early Oxfordian in distal areas, correlative with more proximal Norphlet deposition, because models of Atlantic opening suggest the GoM basin was still smaller at 169 Ma than the mapped expanse of autochthonous salt deposition.

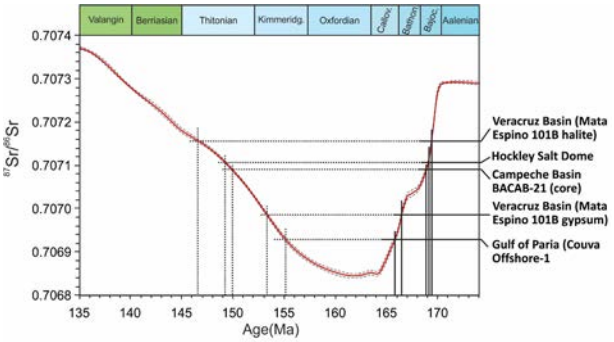

Figure 1. Seawater strontium evolution curve showing the indicated ages of the samples analysed in this study.

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Coeval Early Ediacaran Breakup of Amazonia, Baltica, and Laurentia: Evidence for a large igneous province from SIMS U-Pb dating of mafic dykes from Mexico.

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Laurentia, Baltica and Amazonia formed the last fragment of the Rodinia supercontinent that broke apart during the Early Ediacaran (~630-600 Ma, Fig. 1), leading to opening of the Iapetus Ocean. An essential record to establish such reconstructions and to identify Large Igneous Provinces (LIPs) are coeval dyke swarms that occur over large extensions on formerly adjacent cratons. Plume-related mafic dykes from Baltica (Egersund dykes, [1]) and Laurentia (Long Range dykes, [2]) are reliably dated at 616 ±3 and 615 ±2 Ma, respectively; however, similar dykes were unrecognized in the Amazonia craton or in the Oaxaquia Terrane of Mexico, a Mesoproterozoic basement block located in Rodinia reconstructions between Amazonia and Baltica. Here we report new dating approaches by Secondary Ion Mass Spectrometry (SIMS) from Mexico that proof a previously unrecognized

LIP that produced plume-related magmas over large distances across all cratonic masses involved in final Rodina brake-up and birth of the Iapetus Ocean. Weathering of these LIP basalts may have contributed to Ediacaran Gaskiers glaciation.

1. Polymetamorphic basement of the Chiapas Massif Complex (southeastern Mexico) contains ~1.0 Ga gneisses and anorthosites that were intruded by E-MORB magmas prior to Ordovician high-grade metamorphism [3]. Direct dating of these mafic intrusions is impossible because zircon is either inherited from the basement or metamorphic. This new approach is based on the fact that zirconium exsolved from rutile and ilmenite of anorthosite during thermal overprints, forming metamorphic zircon grains with distinctive growth zones, of which „dark" zircon zones yielded U-Pb ages between 617 ±7 and 608 ±12 MA, reflecting zircon growth in host anorthosite during the intrusion of the „hot" mafic dykes.

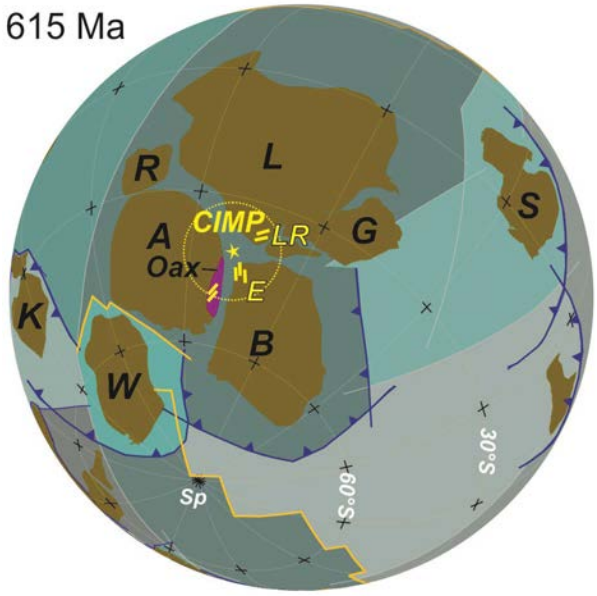

Figure 1: Tectonic geography of the southern hemisphere for Ediacaran times. Rifting of the last piece of Rodinia started with plume-related LIP (Central Iapetus Magmatic Province, CIMP) that encompasses dyke swarms on Greenland, K Kakahari, L, Laurentia, R. Rockall, S, Siberia, W, West Africa, E, Egersund dykes, LR, Long Range dykes, Oax, Oaxaquia (SP, South Pole).

2. A plume-related dike swarm is known from the Rodinia-type Novillo gneiss (northeastern Mexico). In-situ U-Pb micro-baddeleyite (7-10µm) dating yielded the first reliable intrusion age of Novillo dykes at 619 ±9 Ma [4] coeval with Chiapas E-MORB amphibolites, Egersund and Long Range dykes. In addition, a second age group of baddeleyite yielding 545 ±9 Ma is consistent with an earlier 40Ar-39Ar age suggesting recrystallization or Pb-loss during greenschist facies metamorphic overprint.

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PTt-paths of high pressure metamorphic rocks in the Sierra Pie Palo (W-Argentina): evolution of a flat collisional wedge during a „hard" continent-arc collision

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The Sierra Pie de Palo (W-Argentina) is part of a collision zone between the Cuyania microcontinent and the Ordovician Famatina arc at the W-Gondwanan protomargin. The exhumed collisional wedge is unusually wide (≥100 km) with shallowly E-dipping foliations which have accommodated multiple shear events (Mulcahy et al., 2011). In the west metasediments of the Cuyania margin predominate, in the centre metasediments intruded by Mesoproterozoic plutons prevail, and in the east few intrusions attributed to the Famatina arc occur. We provide pressure-temperature-time (PTt)-paths from various parts of the collisional wedge derived by PT pseudosection modelling and dating of metamorphic events. The range of peak PT conditions (8.5-13.4 kbar/475-570°C) and types of PT-paths are similarly distributed throughout the wedge. Three types of PT-paths were recognized: (1) clockwise PT-paths show burial to maximum depth in the lower part of the wedge followed by early thermal relaxation, (2) anticlockwise PT-paths were caused by underthrusting of cold material during convergence or juxtaposition against an upper colder plate, (3) mixed clockwise/anticlockwise PT-paths begin as clockwise PT-paths followed by reburial. Exceptions are samples with granulite facies peak PT-conditions (8-10 kbar/700-760°C) and an anticlockwise PT path similar to occurrences east of the Sierra Pie de Palo (Mulcahy et al. 2014). We attribute these as parts of the overriding Famatina arc.Isotopic ages of metamorphic imprints include: 429±2-434±7 Ma (Lu/Hf mineral isochrones), 460±6 Ma (U/Pb monazite), 404±7-422±8 Ma (Rb/Sr mineral isochrones) and 402±2-440±8 Ma (Ar/Ar white mica). Combined with similar previous age data (Mulcahy et al. 2011; 2014) they cluster around major age peaks at 404±2, 437±2 and 467±7. All isotopic systems used can be shown to date (re)crystallisation of metamorphic minerals. Recrystallization and/or nucleation of new metamorphic minerals was induced by transport of dissolved matter in rising and channelled metamorphic fluids accompanying localised thrusting.

The exposed part of the wide wedge formed during three stages: (1) partial subduction and subsequent extrusion of the leading edge of Cuyania (2) exhumation by normal faulting at structural levels and (3) dissection of the wedge by mid- and upper crustal thrusts generated in the overriding plate, leading to partial reburial of the exhumed wedge. Scattered klippen of the overriding arc were emplaced during stages 2 and 3.

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The new binational Argentinian-German master's program „Applied Geothermics" (San Juan/Bochum)

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Geothermal energy and the associated energy generation are becoming more and more relevant and are increasingly being exploited in Germany during the past years. In particular, the demand for geothermal energy in new buildings for heating and cooling increases annually. Geothermal energy generation is becoming increasingly attractive as an environmentally friendly alternative in the course of the German energy transition. Although Germany has no active geothermal zones (e.g., volcanism) due to its geological conditions, considerable efforts have been made over the last few years to develop geothermal energy. This has resulted in the development of effective new techniques. These experiences are bundled in Bochum at the Ruhr-Universität(RUB) and the International Geothermal Centre (GZB).

Due to the location of Argentina along an active continental margin, where the subduction of the Nazca plate under the South American plate occurs, optimal conditions for geothermal questions and investigations prevail here. The seismicity caused by tectonics and subduction as well as the partly still active volcanism in large parts of South America provides good points of contact for geothermal studies and possibilities of use. These do not only include near-surface and deep geothermal energy such as energy generation, heating and cooling, but also geothermal sources emerging at the surface (forming e.g., salars) in order to investigate the origin of the geothermal energy and to deepen the understanding of the processes leading to these sources. Recent political developments led to a turnaround in renewable energies in Argentina including the acquisition of geothermal energy.

The aim of the project is to bring together the geothermal energy expertise in Bochum with the geothermically ideal conditions and regional geological expertise in San Juan/NWArgentina. This resulted in the newly implemented binational Master's Program (M.Sc.) „Applied Geothermics" for interested students from Germany and Argentina starting in winter term 2019/20. From the German side, it is hosted by RUB and GZB in cooperation with the Department of Applied Geothermal Energy at TU Darmstadt. In Argentina, students will be educated at the Universidad Nacional de San Juan(UNSJ). After completion of the course, a double master´s degree will be awarded to the graduates. Both partner countries will contribute equally to the training of the students: lecture language will be English, but in addition to professional knowledge, intercultural competence will be promoted. Therefore, the first semester will be mainly spent taking German or Spanish courses at the home universities. After that, one semester in Bochum and one in San Juan are planned, followed by the 4th semester for the master's thesis, either at UNSJ or RUB. Requirements include a bachelor degree (or equivalent) in geosciences and a good command of the English language.

Hydro-geothermal circulation systems in the Central Andes of Argentina – The example of Pismanta

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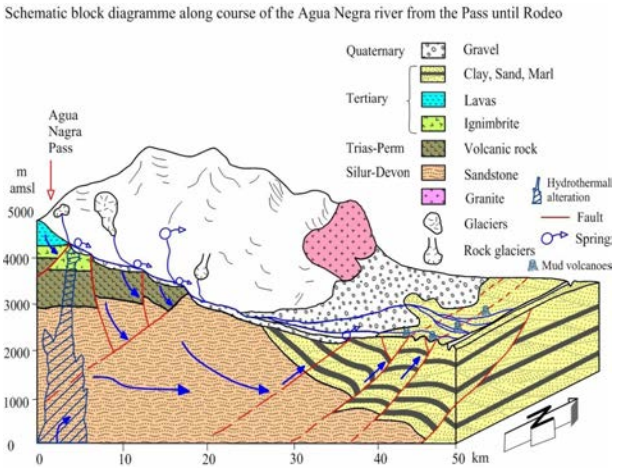
The hydro-geothermal field of Pismanta near Rodeo, San Juan, Argentina, is located in the Argentinean Andes where the Agua Negra river intersects with the North-South trending, depression of the Iglesia Valley (lowest outflow 1500 m). It is limited by the mountain range Cordillera Frontal (Agua Negra Pass, 4780 m) in the West and the Precordillera Occidental (up to 3500 m) to the East. Due to ongoing tectonic activity, North – south trending fault are connecting the deeper aquifers in the Paleozoic sandstones and shales of the Agua Negra Formation with Miocene and Pleistocene-Holocene agglomerates and sandstones, forming a variety of artesian springs on the surface. At most of these artesian springs small and medium size mud volcanoes have formed, marking distinct exit points. In the vicinity of the thermal spa of Baños Pismanta more than 50 artesian springs have been identified and water as well as sediment samples were collected. The water emerging there delivers temperatures between 20°C - 43°C and varying hydrochemical contents. The results of the geochemical and hydrochemical analyses indicate deep hydraulic flow paths from

the central Andes, which occur in the sediments of the Iglesia longitudinal valley via active overthrust and transverse reverse faults.



Urban micro-gravity: study of irregularities in the basement of Querétaro city (Mexico) and subsidence risks

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There are various types of geological risks that can damange infrastructure and security of the civilian population. From the most extreme, such as seismic or volcanic that can be generate immediate danger in inhabited areas, to the „persistent risks", such as subsidence of the land by extraction of water from the subsoil, which occur slowely and imperceptibly but which nevertheless can cause collapse infrastructure due to ground failures that may generate. The main cause of the demage to the infrastructure are the diferential soil movements caused by irregularities in the rocky basement that contain both the sedimentary fill and the water reserves from which the water supply is extracted. In the Querétaro city, demage to the civil structure caused by subsidence of soil began to be documented in the 1980s, although the phenomenon of cracking has been observed in urban areas of cultivation decades earlier.

The present work presents the results of a micro-gravimetry study in the urban area of the Querétaro City, derived from an agreement with the Municipal Planning Institute (IMPLAN) of Querétaro to evaluate the conditions of the subsoil and the distribution of the areas of risk of subsidence in the area of the Historic Center (CH) and surrounding colonies. The study is focused on providing detailed technical information that allows carrying out activities of planning, conservation and remediation of buildings and civil works damaged by this phenomenon. The study was conducted in the January-June 2018 period and included the acquisition of 3510 gravimetric stations using two Scintrex CG5 gravimeters of nominal precision of 1 microGal and the measurement of an equivalent number of topographic stations using differential GPS (one base antenna and two mobile antennas) with a Trimble TDL-450H-R4, whose accuracy after processing ranges from 10 to 15 cm. In total, the gravimetric survey covered 98,420 linear meters; in the CH area, 2759 stations were acquired, including 854 with a separation of 5 meters (4270 lineal meters) and 1905 with a separation of 10 meters (19500 linear meters). About 751 more stations were built around the CH zone, but with a separation of 100 meters, equivalent to an additional 75100 linear meters, although with lower lateral resolution.

The acquired data were corrected by instrumental drift, tides, latitude, Bouguer slab and by terrain. Additionally, we apply the atmospheric correction and building correction. As a result, the complete Bouguer anomaly and its derivatives were genetated. The subsidence model along fault zones was constructed; the displacement of the surface and possible areas to develop faults was obtained. Finally, the irregular hydrological basement was reveled and the map of subsidence risk generated.

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Full crustal scale deformation structures in the Central Andean foreland revealed by recent seismotectonic activity.

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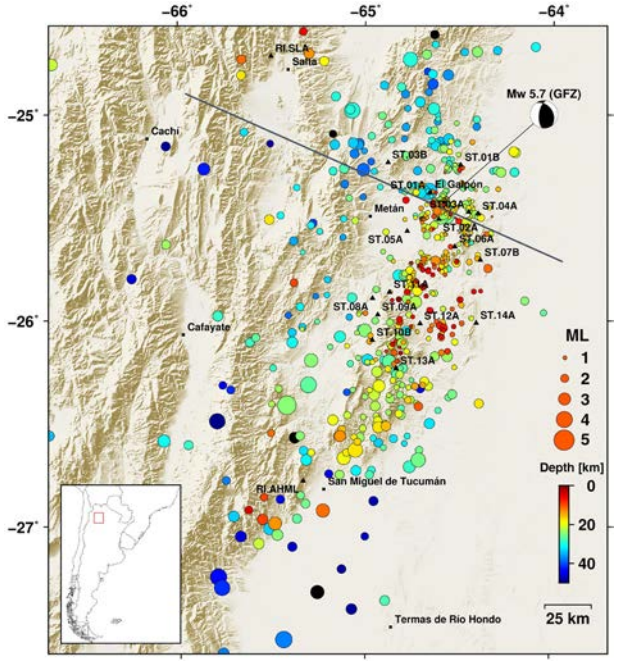
The orogenic history of the Central Andean Foreland incorporates a superposition of multiple tectonic stages with diverse spatial impact. In particular the Santa-Bárbara-System, a morpho-strucural province of the NW Argentine Andes, demonstrateshow inherited structures are recycled and overprinted, while presenting a high crustal seismicity rate of significant magnitude up to M7.

Recently, the need for a better understanding of the neotectonic setting at the Andean mountain front became obvious in 2015, when a Mw 5.7 earthquake hit the town of El Galpón in the Salta Province. For this reason, we installed a local seismological network around the estimated epicenter and noteworthy geological structures. We were able to collect 15 months of continuous data from 13 stations showing numerous earthquakesat different depth levels. Events from crustal seismogenic zones can be clearly distinguished from intermediate (~200km) and very deep (~550 km) inter-slab seismicity.

The spatial distribution of shallow earthquakes displays an extraordinary vertical extension of the seismogenic zone in the earths crust. In this study we show, former ideas of the local geometry of tectonic structures in the Santa-Bárbara-System extend down to the Moho-discontinuity at approximately 40 km; this is twice as deep as thought before.

Besides the separationof spatial seismicity clusters, the identification of seismotectonic structures and their geometries is crucial for understanding the complex multi-stage evolution of the foreland. The studied region comprises Quaternary structures as well as reactivated inherited structures from a long-lasting, altering tectonic history. Further, the integration of geomorphological and applied geophysical analyses deepens the understanding of these structures to shallower depths. In particular, seismic-refraction and 2D electrical resistivity tomographies were carried out for a number of suspected surface fault locations.

The presented study complements the generalcomprehension about a part of the Andean foreland, which incorporates geological, lithological, andsmall- and large-scale tectonic transition zones.



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TERRA NOSTRA

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