Constraints on the lithospheric structure of southern Patagonia from receiver function and surface wave analysis

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The Southern Patagonian Icefield (SPI), the largest temperate ice mass in the Southern Hemisphere, is positioned atop a geologically young and tectonically active region, including a slab window associated with the northward migration of the Chile Triple Junction and characterized by an unusually hot and low-viscosity upper mantle. The SPI is currently undergoing rapid thinning and geodetic evidence of extremely fast uplift rates in the region suggests that southern Patagonia might be highly sensitive to changes in ice mass loads over short time scales, making it an ideal region to study dynamic feedback between mantle rheological structure, climate and surface uplift on time scales of decades to millennia. Here we present some preliminary constraints on the lithospheric structure beneath the SPI from ambient noise and earthquake tomography and receiver function analysis. Seismic data used in this study were recorded by 13 permanent broadband stations that are part of the Chilean, Argentine and GEOSCOPE networks and 28 temporary broadband stations deployed around the SPI. This temporary network was installed in late Fall 2018 and will be operated by Washington University in St. Louis for a period of 20 months in an interdisciplinary and international effort to study the solid earth response of the Patagonian Andes to post-Little Ice Age glacial retreat. We interpret the resolved velocity features in light of previous work and known tectonic features across southern Patagonia and further discuss potential implications for lateral variations in lithospheric thickness and mantle viscosity in the region. Improved constraints on the structure and rheology of the slab window will eventually help us quantify the glacial-isostatic contribution to the observed uplift and more generally help us better understand the dynamics and evolution of the lithosphere along subduction boundaries.

Constraints on glacial isostatic adjustment in the Southern Patagonia Icefield from high-resolution seismic reflection imaging of glacial lacustrine deposits in the Lago Argentino, Argentina

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The Southern Patagonia Icefield, part of the largest southern hemisphere temperate ice complex on Earth, is uniquely positioned above a slab window and northward migrating triple junction, and is characterized by rapid thinning over the past 50 years and by long-term high-amplitude ice fluctuations, which left behind significant and datable moraines. Aggressive retreat, following the Little Ice Age (LIA), ~300 yrs BP, is well documented in moraine systems preserved in the finger lakes portion of the proglacial lakes, where the Patagonian glaciers have receded during the Holocene. Today the region experiences extremely high (~40 mm/yr) GPS uplift rates centered around the icefields, suggesting an isostatic relationship between the cryospheric mass imbalance and the solid Earth response.

Here we present preliminary observational constraints on ice sheet and depositional/erosional history as well as sediment and ice load estimates in the Lago Argentino (Argentina) portion of the Southern Patagonia Icefield, as revealed by newly acquired high-resolution lacustrine seismic reflection data collected on Lago Argentino in the summer of 2019.

The high-quality data consist of ~ 350 km of coincident CHIRP and multichannel seismic reflection data and were acquired using a deep-water Knudsen dual frequency echosounder (12kHz and 200kHz) and a 24-channel MicroEel solid state streamer and a boomer source. The data extend from the current frontal position of the eight outlet glaciers, encased in the Cordillera Patagónica and Andean Foothills, through the glacial valleys, and cross the submerged positions of the Neoglacial and Late-glacial terminal moraines. Data reveal submerged terminal moraines previously unidentified in two glacial valleys, refining the Neoglacial ice history and the extent and volume of ice cover. The combination of ultra-high resolution (CHIRP) and deeper penetration multichannel data result in an ideal imaging of pre-, syn- and post-glacial deposits, which provide an estimate of sedimentation rates and sediment volumes both in the glacial valleys and in the main lake, in addition to revealing a complex interaction between glacial and tectonic processes in the Andean Foothills portion of the Argentino Lake.

High-Resolution Marine Seismic Study on Syn- and Post-Glacial Deposits in Lago Argentino (Patagonia, Argentina)

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We present preliminary results of a Multi-Channel Seismic (MCS) reflection and Compressed High Intensity Radar Pulse (CHIRP) survey across Lago Argentino, Patagonia, Argentina, and its surrounding finger lakes acquired in May 2019. Located at ~50°S and ~72°W, the study area lies within the Southern Patagonian Icefield (SPI) and contains evidence of multiple advances and retreats since the Last Glacial Maximum, including the most recent advance during the Little Ice Age (LIA) ~300 yrs BP. The post-LIA loss of ice has been previously linked to the anomalously fast uplift of the SPI by contributing to regional Glacial Isostatic Adjustment. Former glacial front locations of up to 10,000 yrs BP are preserved in moraines across the Lago Argentino area, which are only well-documented and mapped on land. The newly-acquired MCS and CHIRP data provide the unique opportunity to further constrain the lateral and vertical extents of moraines submerged in the lake – including underwater moraines whose terrestrial counterparts have not yet been well-identified – as well as sediments eroded and redeposited after glacial retreat. A total of ~350 km of 12 kHz Knudsen Deepwater CHIRP data were acquired with largely water-depth dependent parameters. Roughly 225 km of MCS were acquired using a Boomer source and a 50 m, 24-channel Microeel streamer. While the MCS system is capable of penetration sufficient to image the full extent of post-glacial draping sediment packages, underlying glacial deposits, and in some cases tectonic basement structures, the CHIRP system exhibits 0.1 m vertical resolution with a maximum depth penetration of 50 m in soft sediment. The combination of both systems allows for a multi-scale understanding of the pre-, syn- and post-glacial processes that have occurred in the region. Presented in this paper is a 100 km-long MCS line that stretches from the present-day front of the Upsala glacier to the far eastern shore of Lago Argentino. The profile gives a broad overview of the moraines, sediments, and complexity of structures encountered in the dataset. In addition, the variation in morphology of different age terminal and lateral moraines is analyzed in an effort to characterize the conditions of the glacial advance that formed each respective structure.