Fjord sedimentary signature of an advancing glacier in Chilean Patagonia

Piret Loic[1], Bertrand Sebastien[1], Kylander Malin[2] and Moffat Carlos[3]

[1] Renard Centre of Marine Geology, Department of Geology, Ghent University, Krijgslaan 281 S8, 9000 Gent, Belgium
E-mail: loic.piret@ugent.be
[2] Bolin Centre for Climate Research, Stockholm University, 106 91 Stockholm, Sweden
[3] School of Marine Science and Policy, University of Delaware, 272 The Green #111, Newark DE 19716, United States of America

Proglacial sediments hold accurate, continuous, and high-resolution records of past glacier dynamics. In this study, we examine the sediments of Eyre Fjord (49°S), which is fed by the only glacier that is currently advancing in Chilean Patagonia (Pio XI), to gain a better understanding of how the advance of a surging glacier is recorded in marine sediments. An existing bathymetric map demonstrates that the fjord reaches depths between 400 and 600 m below sea level [1]. Pio XI Glacier has experienced a net advance of >10 km since 1945 and its unique behavior has been studied extensively by glaciologists [e.g. 2,3]. It has had several surging phases that last 2-3 years and occur every ~14 years.

To achieve our goal, 30 CTD casts were acquired along a proximal-to-distal longitudinal transect and along three transverse transects in order to better understand the sediment pathways. Nine sediment cores were collected along a longitudinal transect from the glacier's front outwards. The sediment cores were X-ray CT scanned, after which they were split lengthwise, scanned on a Geotek Multi Sensor Core Logger (MSCL) for sediment physical properties and analyzed with an Itrax XRF core scanner to obtain downcore elemental profiles. The activities of short-lived nuclides (210Pb, 137Cs, 234Th) were measured on seven subsamples of the sediment core holding the longest sediment record to assess the sedimentation rates in the fjord.

The CTD profiles show that the highest turbidity values occur at the bottom of the fjord, which indicates that sediment transfer through the fjord in summer primarily happens by means of turbidity currents. The thickness of this sediment plume at the seafloor varies between 20 to 100 m. The activities of 210Pb and 234Th are too low to construct a reliable core chronology. The 137Cs peak, representing 1964 CE, is absent from the longest sediment record, which implies that it contains less than 55 years of mud and suggests that fjord sedimentation rates exceed 2.5 cm/a. The sediment cores consist mainly of fine glacial mud, sometimes intercalated with cm-scale thick sandy layers. Based on their position along the fjord and on the CT scans, the sediment cores were divided in two groups: the 'proximal group' (<35 km away from the glacier front; 5 cores) and the 'distal group' (>35 km away from the glacier front; 4 cores). The distal sediment cores are characterized by prominent bioturbations, likely created by bristle worms (Polychaeta) [4]. The proximal sediment cores are well laminated. Bromine counts and the ratio of incoherent-to-coherent X-ray scattering, which are proxies for marine organic matter content [5], show the highest values in the distal cores, especially in the low-density mud. The downcore profiles of the inorganic elements (Fe, Ti, K, Mn, Zr, Zn, Rb, Sr) are highly correlated with density and magnetic susceptibility profiles. Downcore variations in the concentration of these elements are therefore likely driven by grain-size variations and can be used as high-resolution proxy records of the fjord hydrodynamic conditions. The upper part of the proximal sediment records (above approx. 60 cm) contain sandy layers that are absent from the lower part of the records. These sandy layers are indicative of high energetic conditions and could represent floods. The increase in flood-related sediments through time suggests that the glacier has experienced enhanced hydrological activity in recent times. This could be explained by the onset of a new surging phase of the glacier, i.e. the glacier moves at velocities that are an order of magnitude larger than its mass balance flow velocity.

References

[1] J. Dowdeswell and M. Vásquez, Quaternary Science Reviews 64, 1 (2013).
[2] A. Rivera and G Casassa, Global and Planetary Change 22 (1), 233 (1999).
[3] R. Wilson et al., Annals of Glaciology 57 (73), 119 (2016).
[4] C. Ríos et al., Scientia Marina 69 (S2), 225 (2005).
[5] M. Ziegler et al., Geochemistry, Geophysics, Geosystems 9 (5) (2008).

Keywords: Glacimarine sediment; Fjord; Glacier variability; Advancing glacier; Patagonia