Final conference, Rome October 11, 2016

Modern sediment distribution and composition within the Kongsfjorden, Svalbard Islands

Stefano Miserocchi[1], Alessandra D'Angelo[1,2], Fabrizio Del Bianco[3], Federico Giglio[1], Leonardo Langone[1], Tommaso Tesi[1] and Stefano Aliani[1].

[1] CNR-ISMAR, Italy (s.miserocchi@ismar.cnr.it).
[2] Università degli Studi di Siena, Italy
[3] Proambiente Scrl, Bologna, Italy

Abstract

The Kongsfjorden is 20 km long and 4-10 km wide glacially eroded fjord, elongated in SE-NW direction, located in western Spitsbergen, Svalbard. 12 sediment cores have been sampled using a lightweight SW104 corer during a cruise in 2011 with the purpose to describe modern sediment distribution and composition. Core locations were chosen after a high resolution seismic survey, performed during September 2010, when over 130 miles of sub-bottom profiles were acquired (Fig. 1), in order to delineate the morpho-bathymetric features and surficial seismo-stratigraphy.
The depositional environments of Kongsfjorden is mainly influenced by sediment supply from the glaciers directly into the basins with sediment input decreasing away from the glacier termini (Howe et al., 2003).

Soft sediment deposition over bedrock bottom occurred after the last full glacial re-advance, that would have the effect of removing the previously deposited sediments, transporting them out into the shelf, while the fjord was filled by the advancing ice sheet (Howe et al., 2003). The acoustically well-laminated sediment fill of the ice-proximal basins in Kongsfjorden must therefore be all post-Little Ice Age, younger than 1450–1800 AD (550 to 200 years ago) (Howe et al., 2003). Furthermore, sediments of the inner fjord may have also recorded small-scale fluctuations of the ice fronts related to younger glacial surges. The last glacial surge of Kronebreen glacier occurred in 1948 AD and coincide with recent maximum extent of the glacial complex from which the still-going glacial retreat phase started (Trusel et al., 2010).

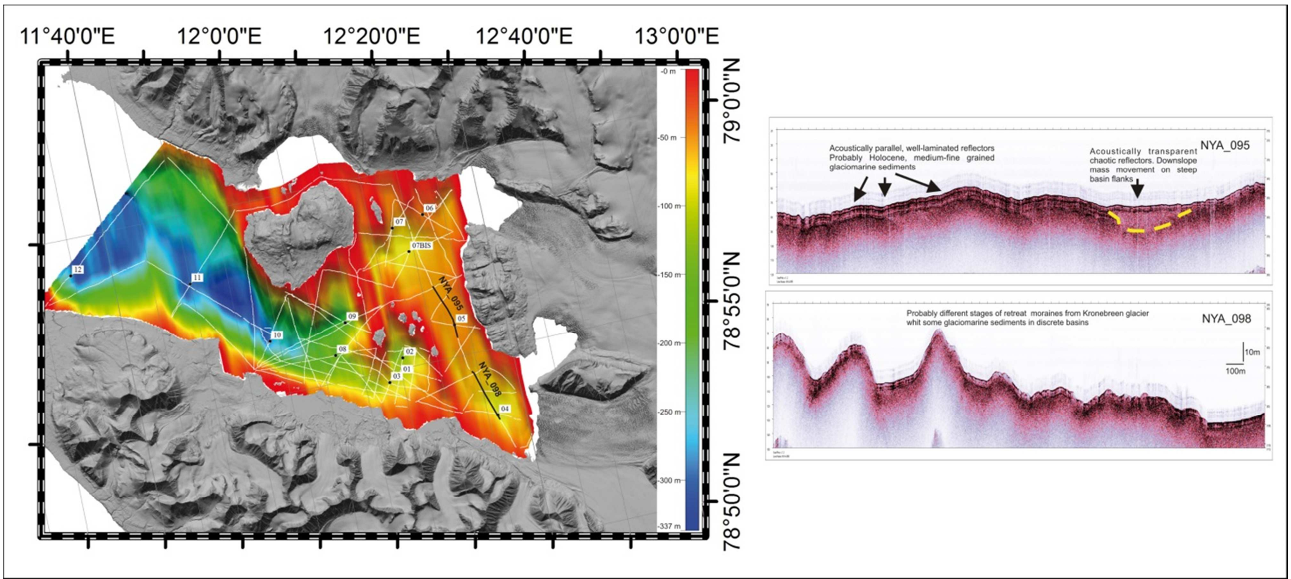

Figure 1. *Morpho-bathymetric map of Kongsfjorden obtained from sub-bottom profiling. Map shows also coring stations and profiling routes. On the right panel n. 2 Chirp Sonar seismic profiles are shown (see map for location).*

Seabed mapping of Kongsfjorden was carried out using a Benthos Chirp III 3-7 kHz sub-bottom profiler, that provides a detailed information about the sediment geometry and acoustic character of the seafloor (e.g. Fig.1). The low-resolution morpho-bathymetric map in Fig.1 was obtained by seafloor picking using SEISPRHO (Gasperini and Stanghellini, 2009). The area located at the inner part of the fjord, close to the calving line, is characterized by the maximum sediment accumulation rate, and a thin (<10m) of medium-fine sediment thickness can be observed, probably due to interaction of 3 proximal ice tongues. Investigated area can be divided into areas of dominant acoustic character based on seismic response of sediment (e.g. Fig.1). Four main categories was found in inner part of Kongsfjorden, these are:
1) acoustically well-laminated with continuous parallel reflector; 2) parallel, irregular-transparent reflectors; 3) transparent-chaotic reflectors; 4) continuous, highly reflective.

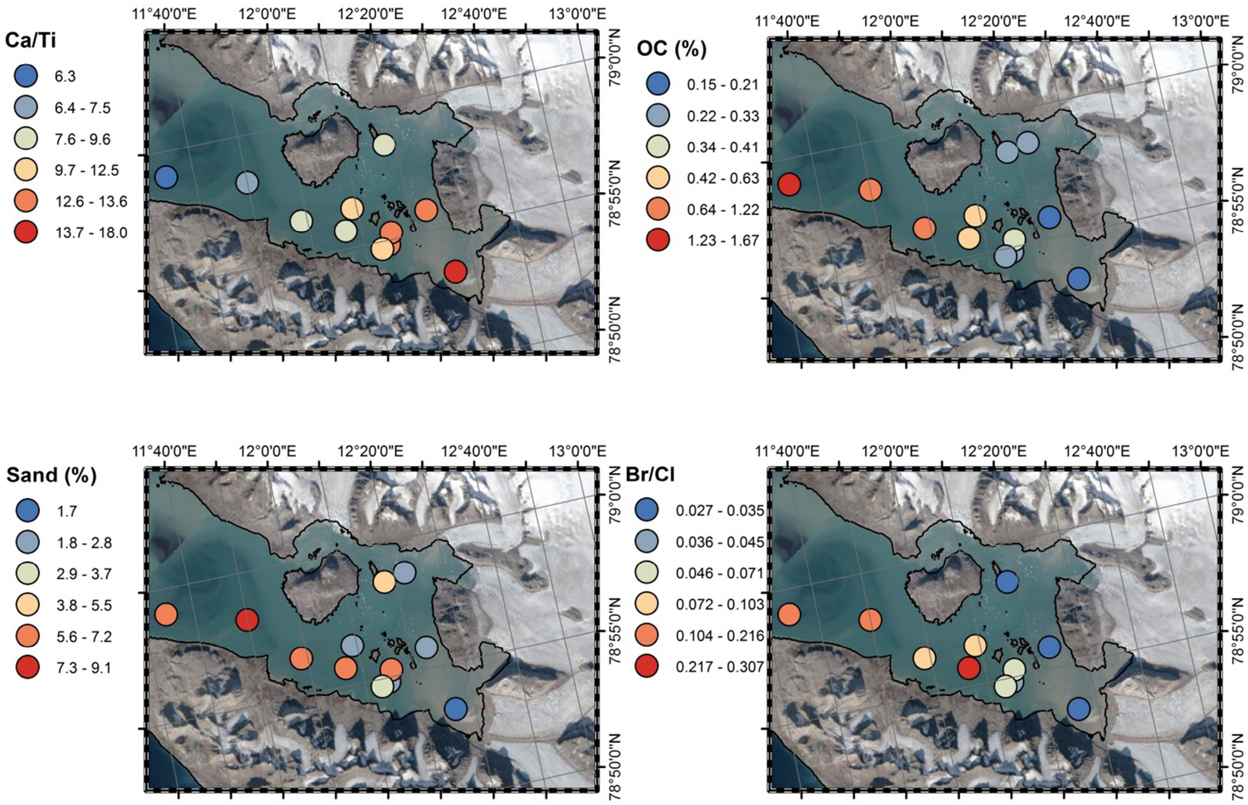

Figure 2. *Distribution of Ca/Ti XRF element ratio, organic carbon (OC) content, Sand content and Br/Cl XRF element ratio for surficial sediment (1.5 cm layer) collected within of the Kongsfjorden.*

The cores, with a maximum recovery of 130 cm, are composed mainly by very fine muddy sediment, sometimes laminated. Sediment accumulation rates (SAR) have been investigated using ^{210}Pb and ^{137}Cs depth profiles resulting in generally highest sedimentation rates near to the glacier fronts. Sediment cores collected in the outer shelf (cores 9, 10, 11, and 12) show a quasi-exponential decline of ^{210}Pb with depth, which allowed an estimate of sedimentation rate applying a constant flux-constant sedimentation rate (CF:CS) model. On the contrary, in the inner fjord, ^{210}Pb activity-depth profiles are characterized by low and fluctuating values, which were interpreted as extremely high sedimentation rates that dilute the ^{210}Pb flux. For cores 1, 5 and 6, it was possible to date modern sediment on the base of the detection of the ^{137}Cs peak, which was attributed to the Chernobyl accident after comparison with the sediment accumulation rate of core 11 obtained by the ^{210}Pb profile (0.31 vs. 0.29 cm/y for ^{210}Pb and ^{137}Cs, respectively). The uppermost part of core 4 does not show any excess of ^{210}Pb, and ^{137}Cs is below the detection limit, which prevented the calculation of any SAR estimate. Site 4 is located very close to the receding front of the Kronebreen and Kongsvegen glaciers. The dating by short-lived radionuclides probably failed due to the very high sediment accumulation in this area.

Organic carbon content of surface sediments (Fig. 2) shows a spatial gradient with values decreasing towards the inner part of the fjord probably which reflects both high accumulation rates and decrease of biological productivity from the open ocean towards the inner fjord.

Ca/Ti and Br/Cl element ratios from X-ray fluorescence core scanning allow defining the sedimentary environments within the fjord. Higher Ca/Ti ratios in superficial sediment layers (1.5 cm) in the inner part of the fjord (Cores 4, 1, 2 ,3 and 5) (Fig. 2) demonstrate the deposition of Ca-rich sediments carried from the Kronebreen and Kongsvegen glaciers catchment area in which Ca-minerals are present. In the outer part of the fjord, lowCa/Ti ratios (Cores 11 and 12) (Fig. 2) reflects the influence of multiple source of sediment within the fjord both from other glaciers or small meltwater rivers. However, down core distribution of Ca/Ti ratio suggests the occurrence of past events during which the glacier influence extended further seaward. Br excess respect to Cl content in hydrated marine sediments reflects the presence of marine organic matter. High Br/Cl ratios in superficial sediment layers in cores 9, 11, and 12 (Fig. 2) demonstrate an enhanced deposition of organic rich sediment in the outer fjord with respect to the inner fjord. Ca/Ti and Br/Cl element ratios profiles in cores 4 and 12 (Fig. 3) confirm the features depicted from surficial sediment composition. Ca/Ti ratios are systematically higher in core 4 (whole core average 15.76) with respect to core 12 (average 7.41) evidencing the presence of the Kronebreen and Kongsvegen sediment source close to the area of core 4; nevertheless in the deep part of core 12 the layers from 33.5 to 37.5 cm present enhanced Ca/Ti (average 10.41) that could indicate an event of sediment transport from the inner part of the fjord. Br/Cl ratios are systematically lower in core 4 (average 0.03) with respect to core 12 (average 0.11 with peaks greater than 0.20 in the upper layers) showing a sedimentary environment favourable to organic matter preservation in the outer part of the fjord.

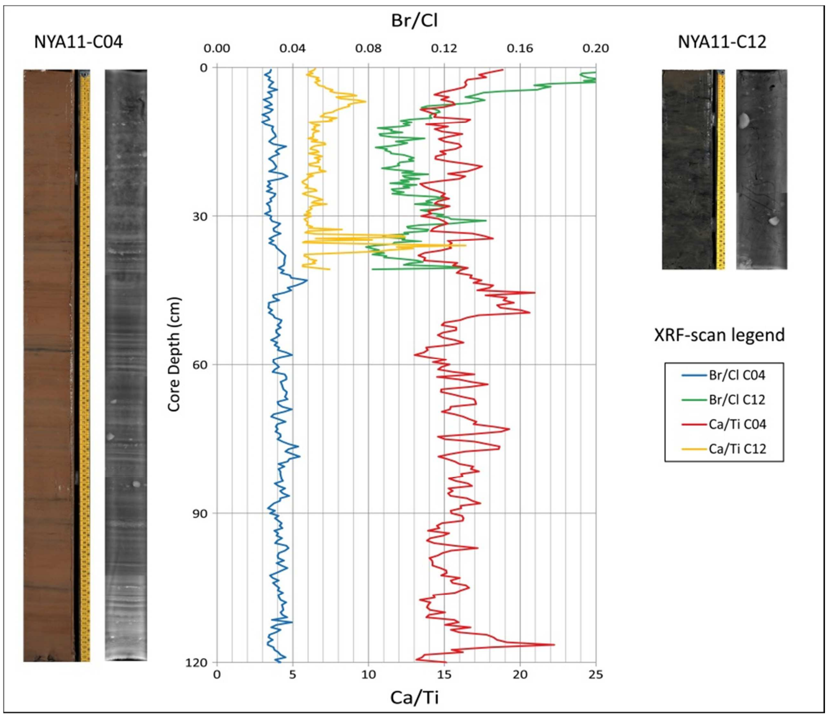

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Figure 3. *Photograph, X-ray image and XRF scan data for sediment cores C04 and C12. XRF element ratio profiles of Ca/Ti and Br/Cl were acquired at 0.5 cm resolution for core C04 (120 cm-long) and at 0.3 cm resolution for core C12 (41 cm-long).*