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Palaeoclimatic changes in Kveithola, Svalbard, during the Late Pleistocene deglaciation and Holocene: Evidences from microfossil and sedimentary records

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ABSTRACT

Climate changes are reflected in the Arctic ecosystem history over different timescales. We use a multi proxy-based approach for palaeoenvironmental and palaeoclimatic reconstructions, conducted on sediment cores, compared with summer insolation and Greenland ice core $\delta^{18}O$ data in order to establish a framework for climate changes from Late Pleistocene to late Holocene. Our dataset includes the results compiled from a sediment core, collected on the middle slope of the Kveithola Trough Mouth Fan (South of Svalbard) during the CORIBAR cruise (2013). The studied core presents remarkable lithological and magnetic susceptibility similarities with cores recovered in the same area during the SVAIS (2007) and the OGS-EGLACOM cruise (2008), allowing the construction of the age model. The results indicate that during the last 14.5 cal ky BP advances and retreats of the Svalbard Barents Sea Ice Sheet were strictly linked to the interplay of Atlantic and Arctic water inflows to the study area. During the deglaciation, from the Last Glacial Maximum to the onset of the Holocene, the climate underwent a series of abrupt changes including the Bølling-Allerød warm interstadial and the Younger Dryas cold event. During the early Holocene, the investigated area was dominated by enhanced warm Atlantic water inflow, which was concomitant with summer insolation increase, characterizing the Holocene Thermal Maximum. Conversely, the late Holocene was governed by deteriorating climatic conditions, with predominant Arctic/Polar water inflow on the surface water masses off Western Svalbard, possibly associated with summer insolation decline due to orbital forcing.

1. Introduction

The polar oceans are sites of deep-water formation driving the thermohaline circulation and affecting climate on a global scale. Palaeoclimatic reconstructions can be achieved through proxies, such as microfossil assemblages and clay mineral distribution, that provide key information for water masses provenance and environmental targets such as sea surface temperature (SST), salinity, sea-ice cover and marine biological productivity.

Here we focus on the marine biotic response to Late Pleistocene and Holocene climate changes, using an integrated approach on a sediment core. The aim of the present research is the reconstruction of the palaeoclimatic and palaeoenvironmental changes in the Kveithola glacial trough system (South of Svalbard) during the Late Pleistocene deglaciation and the Holocene on the basis of the microfossil phyto and zooplankton assemblages and clay mineral distribution. The Late Pleistocene deglaciation was an unsteady process; ice sheets, at various times, temporarily arrested, advanced and/or retreated affecting the climate of the surrounding areas. According to Winsborrow et al. (2010) the deglaciation of the SW Barents Sea (Bjørnøyrenna glacial trough system) initiated at ca. 15.5 cal ka BP, while Jessen et al. (2010) and Lucchi et al. (2013) indicated deglaciation on the NW Barents Sea started at ca. 20.5 cal ka BP. The subsequent Holocene is the youngest phase of the Earth climate history that began when the last glaciation ended. During the Quaternary, commonly preserved microfossil groups in polar areas include calcareous nannofossils (Backman et al., 2009), diatoms (Koç and Schrader, 1990) and planktonic foraminifera (Wollenburg and

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Kuhnt, 2000). The distribution of these microfossils has been investigated in a sediment core, collected from the Kveithola Trough Mouth Fan (TMF) middle slope in the framework of the international project CORIBAR, sharing objectives with the International Polar Year (IPY) Activity 367 NICESTREAMS (Neogene Ice Streams and Sedimentary Processes on High-Latitude Continental Margins). The results from the studied core were compared with the dataset obtained from neighbouring sediment cores recovered during IPY 2007–2009: the SVAIS project (Development of an Arctic ice stream-dominated sedimentary system: The Southern Svalbard continental margin), funded as Spanish IPY research program, and the EGLACOM project (Evolution of a glacial Arctic continental margin: The Southern Svalbard ice stream-dominated sedimentary system), funded by the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), as contribution to IPY Italian activity.

The study of the Kveithola represents an excellent opportunity to improve the understanding of palaeoclimate variations over the approximately last 14.5 cal ky BP, because of the presence of an expanded and continuous sedimentary sequence from the last deglaciation to the Holocene. Past climatic reversals had major impacts on Arctic regions over timescales much shorter than orbital cycles and they provide a unique framework for today's climatic changes.

2. Study area

The Kveithola Trough Mouth Fan (TMF) is situated North-West of the Bjørnøya island and South of the Spitsbergenbanken, the shallowest bank in the Barents Sea having a water depth of 30–80 mbsl (Rüther et al., 2012) (Fig. 1a). The Kveithola is a glacial U-shaped trough with an East-West orientation and it is about 90 km long, 15 km wide, with a water depth that ranges between 200 and 400 mbsl (Rebesco et al., 2011; Rüther et al., 2012). The Kveithola, part of the Storfjorden glacial system, was carved by ice streams that during the last glacial period drained ice from both Svalbard, located in the Northern area, and Bjørnøya, located in the Southern area (Andreassen et al., 2008; Rebesco et al., 2011). The Storfjorden-Kveithola palaeo-ice stream is a small system compared to the major drainage systems of the Barents Sea (Svendsen et al., 2004); however, it contains a valuable high-resolution sedimentary and climate archive for its location close to the Fram Strait that represents the only deep-sea gateway for water masses exchange between the Arctic Ocean and the Greenland-Norwegian Sea. Two main currents interact in the study area: the West Spitsbergen Current (WSC) and the Eastern Spitsbergen Current (ESC) (Fig. 1b). At about 70°N the Norwegian Atlantic Current (NwAC) splits into the North Cape Current (NCaC), that flows into the Southern part of the Barents Sea, and the West Spitsbergen Current (WSC), that carries on Northward along the Western slope of Svalbard into the Arctic Ocean (Blindheim and Rey, 2004; Groot et al., 2014). The WSC transports relatively warm (6 to 8 °C) and salty (35.1 to 35.3‰) Atlantic water, keeping this area free of ice year-round (Aagaard et al., 1987). A branch of the WSC mixes with Polar water moving North of Svalbard and enters again the Barents Sea East of Spitsbergen. This current, the Eastern Spitsbergen Current (ESC), is characterized by lower temperature (0 °C) and salinity (34.3–34.8‰) with respect to the WSC being covered by seasonal sea-ice during winter that causes dense deep water formation by brine rejection (Loeng, 1991). The extent of the sea-ice cover is controlled by the Polar and Atlantic surface water boundaries, that constrain the location of the two oceanic fronts, the Polar front (PF) and the Arctic front (AF) (Fig. 1b). The PF corresponds to the average summer sea-ice margin and the AF is associated with the maximum extension of sea-ice during winter (Zamelczyk et al., 2012).

3. Material and methods

This study is based on the investigation of a 974 cm long gravity core (GeoB17603-3, in the following indicated as 17603-3) recovered on the

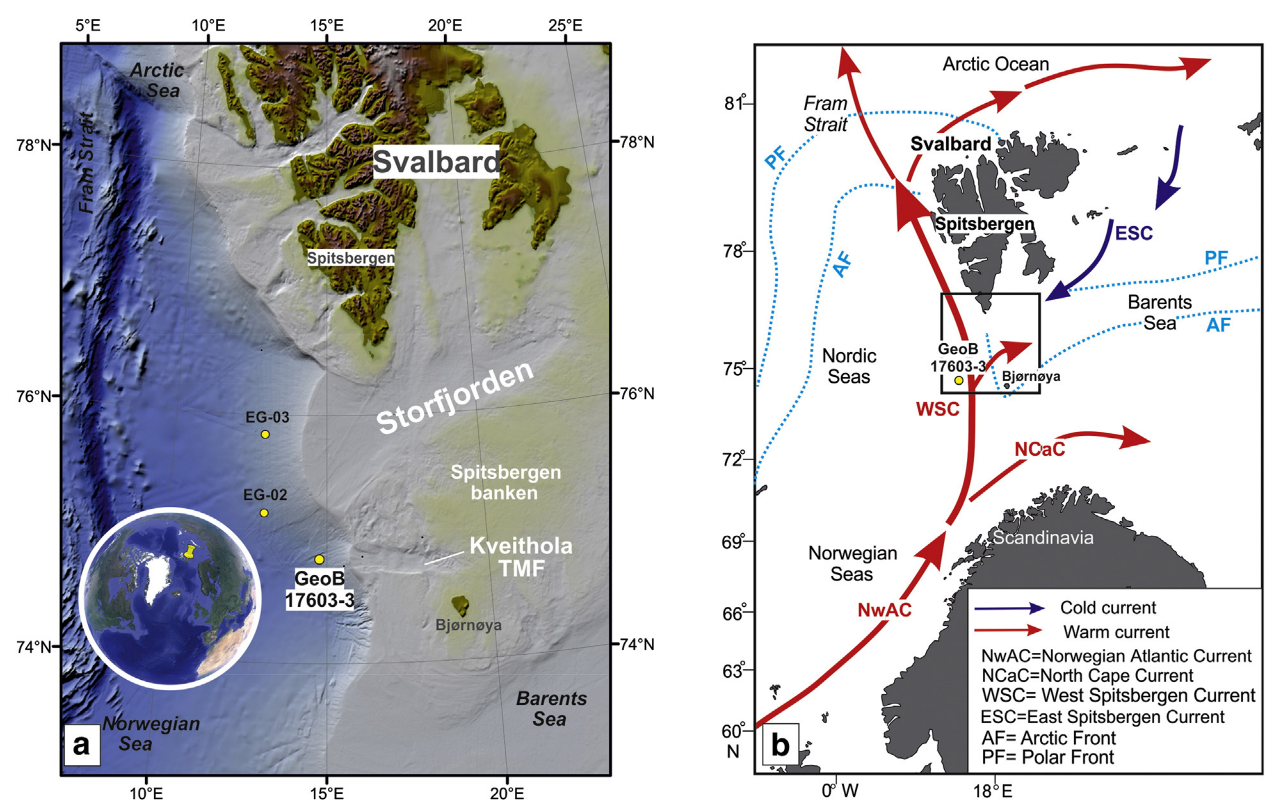

Fig. 1. a – Location of the study area. Yellow dots indicate the studied core CORIBAR 17603-3 and other cores also discussed in the text (EGLACOM cores); TMF = Trough Mouth Fan; b – oceanographic circulation in the NW Barents Sea. The black box indicates location of the study area. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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