

Clay mineral analyses in Post Last Glacial Maximum sediments recovered South of Svalbard (NW Barents Sea, Arctic)

Maria Elena Musco^{1,2}, Giovanna Giorgetti¹, Renata Giulia Lucchi², Andrea Caburlotto² and CORIBAR Scientific Party

¹Università di Siena, mmusco@inogs.it;

²OGS, Istituto Nazionale di Oceanografia e Geofisica Sperimentale-OGS

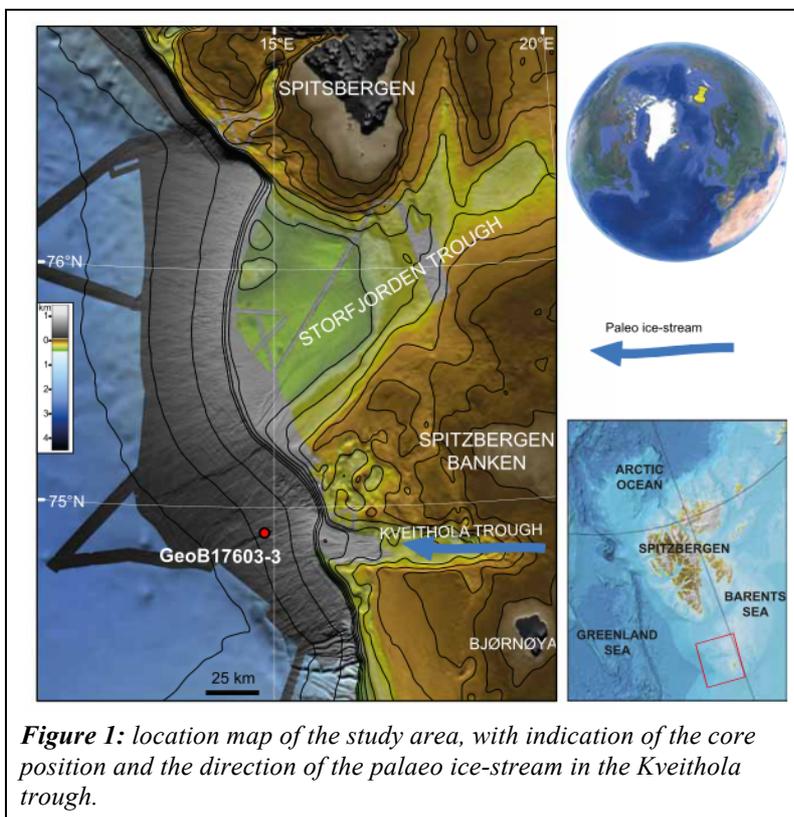
Abstract

Investigation of post Last Glacial Maximum sediments of the North-Western Barents Sea continental shelf can provide information about the ice-stream pathways and the onset of the deglaciation of the western terminus Barents Sea Ice Sheet. The trough-mouth fan slope facing the Kveithola glacial trough has been investigated during the International Cruise CORIBAR on board the RV-Maria S. Marien (July-August 2013). Here we present some preliminary results on clay mineral analyses of core GeoB17603-3, aiming to elucidate the variations in the sources of sediment and strength fluctuations of the North Atlantic Current (NAC).

Introduction

The Kveithola depositional system is a small glacial trough, located South of the Svalbard Archipelago (North-western Barents Sea) (Fig. 1). The Kveithola trough has an E-W orientation and it is 90 km long, 15-20 km wide and 200-400 m deep (Rüther et al., 2012; Bjarnadóttir et al., 2013). During the last glaciation (MIS-2) it hosted ice streams that contributed to the build-up of the Kveithola trough-mouth fan (TMF). TMFs are sedimentary depocenters derived primarily from debris-flow accumulation at the front of ice troughs on continental shelves (Vorren et al., 1989, 1998). The marine sedimentary record of TMFs provides the most direct proxies on ice-stream dynamics during glacial periods, giving indications on the onset of deglaciations and

environmental/climatic variability during interglacials. Core GeoB17603-3 is a 974 cm-long gravity core, collected from the middle slope, containing a very expanded, continuous sedimentary sequence that deposited after the Last Glacial Maximum (LGM). This core records important information about the extent of the North-western terminus of the Barents Sea Ice Sheet (BSIS). Clay mineral composition of marine surface sediments can provide information about source areas and transport mechanisms of terrigenous material. Illite is a typical detrital clay mineral of high latitudes, as well as chlorite both deriving from physical weathering and glacial erosion (Junttila et al., 2010). Kaolinite is usually concentrated in tropic-humid areas (Fagel, 2007). In



polar areas it can be found in sedimentary deposits that were formed during past warmer and wetter climatic conditions, or it can be displaced northward from lower latitudes through plate motion, where these deposits currently exist (Stein, 2008). Smectite of oceanic origin normally forms by hydrothermal alteration and/or meteoric weathering of basaltic materials (Chamley, 1989) and in this area it is generally used as a proxy for the NAC strength (cf Junttila et al. 2010).

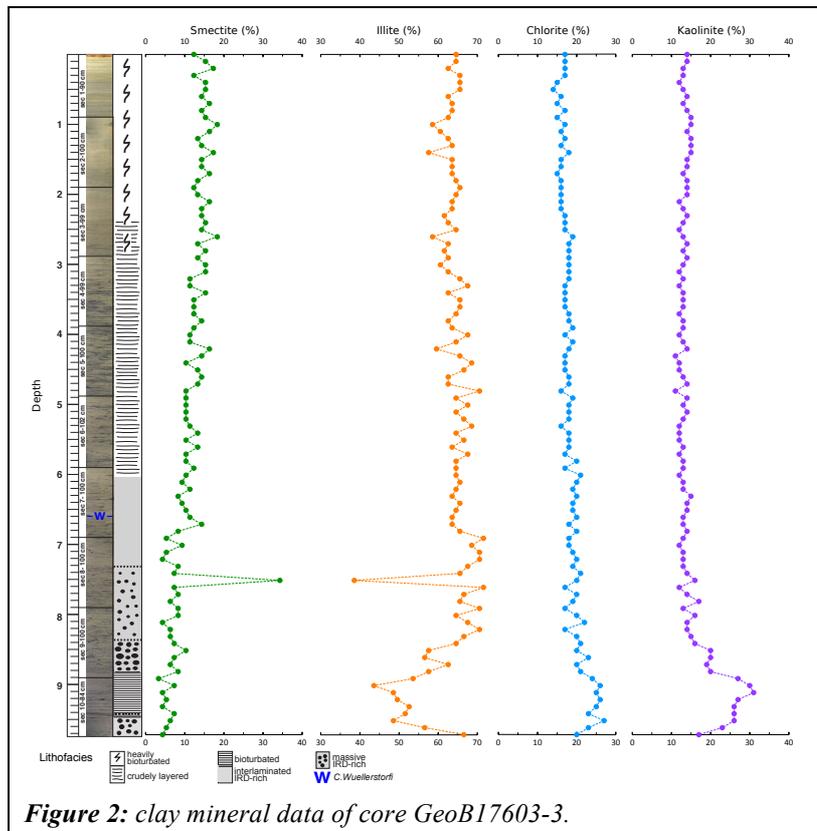
Methods

98 samples were collected from core GeoB17603-3 at every 10 cm. The sand and mud fractions were separated by wet sieving, then the silt and clay fractions were separated by centrifugation. The computation of centrifuge run times and speeds to settle the different size particles are obtained from a modification of the Stokes' Law, taking account of the size of the particles, the density in media at different temperatures, specific gravity and viscosity (Poppe et al., 1988). The clay smear slides were analysed with a Phillips PW1710 X-ray powder diffractometre, using $\text{CuK}\alpha$ radiation (40 kV, 40 mA). Each sample was analysed between 2° and $40^\circ 2\theta$, with a step size of $0.02^\circ 2\theta$ in the air-dry state and after ethylene glycol solvation, which permits the expansion of smectite to a basal spacing of about 17 Å. A slower scan, between 23° and $25.5^\circ 2\theta$, with a step size of $0.005^\circ 2\theta$ was performed on the glycolated samples, to obtain a better resolution of the chlorite-kaolinite twin peak. MacDiff software version 4.2.6 was used to estimate the semi-quantitative abundance of the dominant clay minerals from their main basal reflections in the glycolated state. The relative percentage of each clay was computed using weighting factors (Biscaye, 1965). Clay mineral percentage standard deviations were calculated as: illite $\pm 1\%$, smectite $\pm 1\%$, chlorite $\pm 2.5\%$ and kaolinite $\pm 2\%$ (Damiani et al., 2006).

Results

Core GeoB17603-3 contains five sedimentary facies. From the top to the bottom of the core there are heavily bioturbated sediments (0-240 cm), overlying crudely layered sediments (240-605 cm). From 605-880 cm there are bioturbated IRD-rich sediments, with a very abundant IRD interval (835-880), that are on top of interlaminated sediments (880-940 cm) and the sequence ends with an interval of IRD-rich sediments (940-974 cm). These facies were interpreted as the product of depositional processes linked to the inception of deglaciation after the LGM and the BSIS collapse in this area, that led to climatic conditions more favourable to bioproductivity (Lucchi et al. 2013).

The predominant clay mineral in core GeoB17603-3 is illite (33-66%), followed by smectite (3-34%), kaolinite (11-31%), and chlorite (12-25%) (Fig. 2). The content of illite is variable along the core, it reaches minimum values at the base in the massive IRD-rich and in the interlaminated sediments (840-974 cm). Here illite has an opposite trend with respect to chlorite and kaolinite, that maintain almost stable lower



percentages in the other sediment facies. The minimum content of smectite corresponds to the laminated and IRD-rich sediments at the bottom of the core, while its values increase progressively up-core from the bioturbated IRD-rich sediments to heavily bioturbated sediments where maximum values are recorded. There is an evident opposite correlation between smectite and illite starting from the depth of 470 cm.

Conclusions

The relationships among the main clay minerals give us indication of the changes in sediment source areas that appear to be strictly associated to the type of depositional process acting at time, in relation to palaeoenvironmental/palaeoclimatic conditions. At the base of the core, kaolinite and chlorite enriched sediments associated to deposition from turbid meltwaters (laminated sediments and/or with massive IRD) is associated to the main phase of glacial retreat. The reduction of both chlorite and kaolinite contents in the overlying bioturbated IRD-rich sediment facies is associated to the end of the main deglaciation phase (less continental input) with onset of a stronger NAC resulting in the enhanced smectite content. The sudden appearance of the benthic foraminifera *Cibicides Wuellerstorfi* in the upper part of the bioturbated IRD-rich sediments marks the beginning of a consistent climatic amelioration (Rasmussen et al., 2007).

References

- Biscaye, P.E., 1965. Mineralogy and sedimentation of recent deep-sea clay in the Atlantic Ocean and adjacent seas and oceans. *Bull. Geol. Soc. Am.*, 76, 803-832.
- Bjarnadóttir, L.R., Rùther, D.C., Winsborrow, M.C.M., Andreassen, K., 2013. Grounding-line dynamics during the last glaciation of Kveithola, W Barents Sea, as revealed by seabed morphology and shallow seismic stratigraphy. *Boreas*, 42, 84-107.
- Chamley, H., 1989. *Clay Sedimentology*. 623 pp.
- Damiani, D., Giorgetti, G., Memmi Turbanti, I., 2006. Clay mineral fluctuations and surface textural analysis of quartz grain in Pliocene-Quaternary marine sediments from Wilkes Land continental rise (East-Antarctica): Paleoenvironmental significance. *Mar. Geol.*, 226, 281-295.
- Fagel, N., 2007. Clay minerals, deep circulation and climate. *Dev. Mar. Geol.*, 1, 139-184.
- Junttila, J., Aagaard-Sørensen, S., Husum, K., Hald, M., 2010. Late Glacial-Holocene clay minerals elucidating glacial history in the SW Barents Sea. *Mar. Geol.*, 276, 71-85.
- Lucchi, R.G., Camerlenghi, A., Rebesco, M., Colmenero-Hidalgo, E., Sierro F.J., Sagnotti, L., Urgeles, R., Melis, R., Morigi, C., Bárcena, M.-A., Giorgetti, G., Villa, G., Persico D., Flores, J.-A., Rigual-Hernández, A.S., Pedrosa, M.T., Macri, P., Caburlotto A., 2013. Postglacial sedimentary processes on the Storfjorden and Kveithola trough mouth fans: Significance of extreme glacialmarine sedimentation. *Glob. Planet. Change* 111, 309-326.
- Poppe, L.J., Fredericks, J.J., Hathaway, J.C., 1987. A computer program to calculate centrifugation parameters for sedimentation analyses. *Comp. Geosci.*, 14(4), 541-545.
- Rasmussen, T., Thomsen, E., Ślubowska, M.A., Jessen, S., Solheim, A., Koç, N., 2007. Paleoceanographic evolution of the SW Svalbard margin (76°N) since 20,000 14C yr BP. *Quat. Res.*, 67, 100-114.
- Rùther, D.C., Bjarnadóttir, L.R., Junttila, J., Husum, K., Rasmussen, T.L., Lucchi, R.G., Andreassen, K. 2012. Pattern and timing of the northwestern Barents Sea Ice Sheet deglaciation and indications of episodic Holocene deposition. *Boreas*, 41, 494-512.
- Stein, R., 2008. Arctic Ocean sediments, Processes, proxies and Paleoenviroment. *Dev. Mar. Geol.*, 2, 592 pp.
- Vorren, T.O., Lebesbye, E., Andreassen, K., Larsen, K.B., 1989. Glacigenic sediments on a passive continental margin an exemplified by the Barents Sea. *Mar. Geol.*, 85, 251-272.
- Vorren, T.O., Laberg, J.S., Blaume, F., Dowdeswell, J.A., Kenyon, N.H., Mienert, J., Rumohr, J., Werner, F., 1998. The Norwegian-Greenland sea continental margins: morphology and late Quaternary sedimentary processes and environment. *Quat. Sci. Rev.*, 17, 273-302.