INTEGRATED DATA-MODEL ASSESSMENT OF ORGANIC MATTER REACTIVITY IN THE CHANGING BARENTS SEA SEDIMENTS

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Organic matter (OM) deposition, remineralisation, and burial in marine sediments play a crucial role in coupling benthic and pelagic nutrient cycles over a range of time scales. However, the mechanistic linkages between those processes are not fully understood. OM reactivity integrates the influence of both a) OM fluxes to the seafloor and b) the nature of materials being delivered for benthic processing. Thus, model-derived OM reactivity assessments allow us to better understand benthic-pelagic coupling and how it impacts carbon cycling and climate (Arndt et al., 2013). Further, interrogating OM reactivity alongside the main characteristics of the depositional environment represents a unique opportunity for establishing a systematic understanding of OM cycling. The Barents Sea is subject to large spatial and temporal variability in sea ice cover as a result of oceanographic and atmospheric forcing. Those factors modulate ice formation and retreat, water column stratification and mixing, as well as phytoplankton productivity. Such processes have a strong impact on benthic-pelagic coupling and on OM reactivity. Our aims are to quantitatively investigate OM reactivity patterns along the sea ice gradient and to understand how OM sources as well as ageing processes influence OM preservation and burial. Ultimately, our objective is to improve our mechanistic understanding of OM cycling and to inform forecasts of future changes for the Barents Sea and the wider Arctic Ocean.

We employ state-of-the-art Reaction-Transport Modelling (RTM) (e.g. Arndt et al., 2013) to reconstruct and quantify benthic dynamics in the Barents Sea along the 30°E S–N transect (74°N – 81°N). The RTM is constrained by comprehensive sediment and porewater observations at 5 benthic stations along the S–N transect with similar sediment types (mainly silty mud), from similar water depths (~280 - 370 meters) and crossing the Polar Front/winter sea ice edge in the 2017 summer. RTM results are interrogated alongside bulk (%TOC, $\delta^{13}C$, and $\Delta^{14}C$) and molecular (*n*-alkanoic acids) OM parameters. RTM results produce a quantitative picture of the sedimentary OM reactivity across the sea ice margin. The permanently ice-free, southern sector is characterized by a more reactive ($k = 1.2 \cdot 10^{-2}$ yr^{-1}), yet heterogeneous mixture of OM at the sediment-water interface (SWI). OM buried in this sector is composed of a mixture of fresh and labile material that is relatively quickly degraded in the uppermost sediment layers, and recalcitrant OM which is slowly degraded with increase of depth/time/age (Fig. 1a). The northern, winter ice-covered Barents Sea sediments exhibit more unreactive OM at the SWI ($k = 1.8 \cdot 10^{-3}$ yr^{-1}), which is characterised by a homogeneous distribution and is composed of unreactive materials (Fig. 1b). Differences in reactivity reflect on the depth-integrated rates of OM degradation, with four times higher rates in the ice-free sector (237 µmol cm^{-2} yr^{-1}) compared to the ice-covered region (54 µmol cm^{-2} yr^{-1}).

Bulk and molecular characterization of OM (Stevenson et al., *this volume*) reveals trends in OM source and cycling in the Barents Sea (Fig. 1 c – f). The data can be interpreted as shift from young, marine OM at the SWI to aged, terrestrial OM with increase of burial depth, which is more accentuated at the northern stations. Additionally, we detect a marked OM decline associated with OM ageing and burial, especially in the ice-free region. The *n*-alkanoic acid distributions are markedly distinct at the SWI, with strong predominance of short-chain (< *n*-C_{22}) homologues in the ice-free region. We observe a progressive and preferential loss of those short-chain, labile lipids in both areas.

The geochemical data broadly support the RTM-derived OM reactivity estimations. In the southern, ice-free Barents Sea, inputs of labile, marine OM from seasonally productive overlying waters to the SWI results in highly reactive OM but also high rates of degradation, which are enhanced by biological mixing in the uppermost sediments. This processing produces strong OM loss, as well as ageing and a shift in OM sources with preferential degradation of marine pools. In contrast, due to limited productivity in the overlying waters and restricted input of fresh OM, the ice-covered, northern Barents Sea exhibits less reactive OM and lower rates of degradation, and reduced loss of OM with depth. Overall, our integrated data-model approach helps to disentangle processes driving OM cycling in the Barents Sea sediments and represents a step forward for developing a mechanistic framework. This is crucial for understanding the changes in benthic-pelagic coupling driven by sea ice retreat, as well as producing prognostics of long-term changes in the Arctic Ocean.

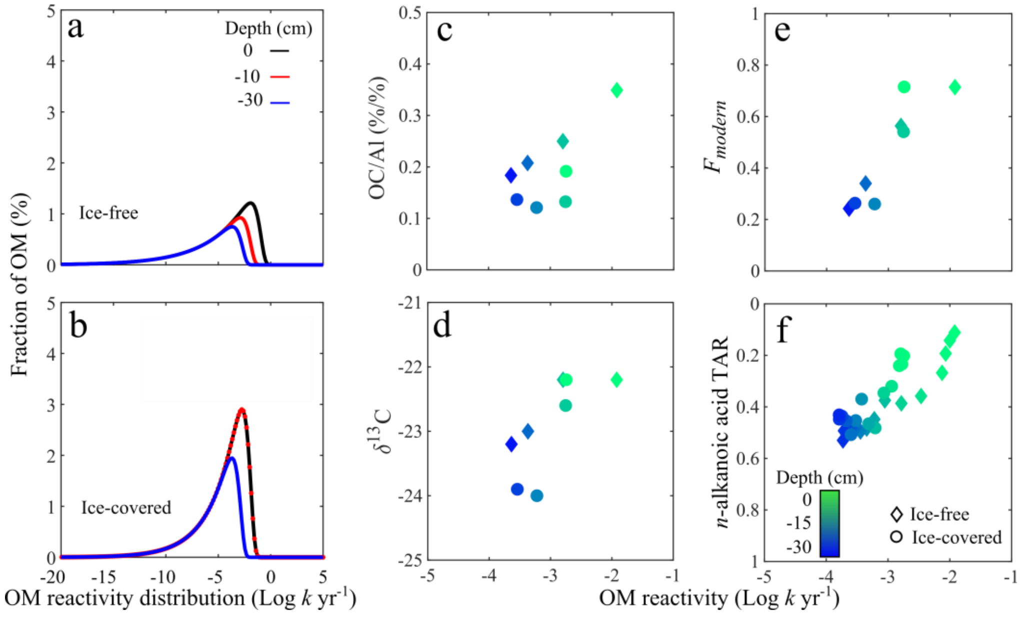

Figure 1 *Model-derived OM reactivity distributions (a – b); OM reactivity vs. bulk OM characterization (c – e) and molecular OM characterization (f).*

Arndt, S., Jørgensen, B.B., LaRowe, D.E., Middelburg, J.J., Pancost, R.D., Regnier, P., 2013. Quantifying the degradation of organic matter in marine sediments: A review and synthesis. Earth-Sci. Rev. 123, 53–86.

Stevenson, M.A., Faust, J., Freitas, F.S., Henley, S.F., Hilton, R.G., März, C., Godbold, J.A., Solan, M., Tessin, A., Abbott, G.D., (this volume). Changes in sedimentary organic matter burial across a retreating sea ice gradient in the Arctic Barents Sea.