The Indian-Atlantic Ocean gateway during the Pliocene: current dynamics and changing sediment provenance

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The Pliocene epoch represents a discrete interval which reversed a long-term trend of late Neogene cooling and is also the most recent geological interval in which global temperatures were several degrees warmer than today. It is therefore often considered as the best analogue for a future anthropogenic greenhouse world. However, there is growing evidence that the Pliocene was not a stable period but can rather be subdivided in several distinct climate phases. Our understanding of Pliocene climate variability in the Southern Hemisphere, and especially in the Atlantic-Indian ocean gateway, is limited by scarce marine records and poor age control on existing terrestrial climate archives. At five drilling locations IODP Exp. 361 recovered high resolution complete late Miocene to Pleistocene sections (Hall et al., 2017). Our research proposal is based on the Sites U1474 (Natal Valley), U1475 (Agulhas Plateau), and U1479 (Cape Basin) forming a latitudinal transect. The main focus is on the interplay between northern and southern sourced deep water masses in the Atlantic-/Indian Ocean gateway during the Pliocene and combines chemical, physical property and seismic methods. Our research is driven by three working hypotheses:

Seismic stratigraphies for the last 6 Ma and sediment drift growth in the Atlantic-Indian gateway are mainly controlled by bottom water flow changes

Using the sediment archives and physical property records from IODP Exp. 361 (Hall et al., 2017) we aim to construct and compare detailed seismic stratigraphies for the Agulhas Plateau, the Natal valley and the Cape basin for the last 6 Ma. At all Exp. 361 sites *P*-wave velocity and density records enable detailed correlations of drilling results and site survey data through the calculation of synthetic seismograms. Our working hypothesis implies that seismic reflection patterns and sediment accumulation during the Pliocene are closely linked to deep water circulation changes associated with climate Pliocene phases. Furthermore four distinct high latitude Pliocene glaciation events have been identified. We speculate that these phases and events have led to deep water circulation changes in Agulhas region, have altered the sediment physical properties and thus may be recognized as reflectors in the seismic profiles. How did the sediment input of terrigenous vs. biogenic sediment components in the gateway change during these events? Are these changes driven by dilution, dissolution, or productivity? We strive to answer these questions by interpreting edited and in-situ corrected physical core scanning records in combination major element variabilty derived from post cruise XRF-scanning.

Trajectories and intensities of deep water masses in the Agulhas region during the Pliocene were influenced by Antarctic ice volume rather then by the closure of the Central American Seaway.

The Exp. 361 drill sites offer the possibility to inter-correlate different flow speed proxies and to derive a detailed picture of flow changes during the Pliocene. By comparing core-measurements of sortable silt ($\overline{SS}$), physical properties and XRF-core scanning data with seismic features we will tie the major flow speed changes to our seismic grid covering the Agulhas Plateau such that changing current intensities and pathways can be mapped together. Here we hypothesize that these changes are mainly driven by climate (Antarctic ice volume). How have the sedimentation patterns changed under the growing influence of North Atlantic Deep Water (NADW) during the Pliocene? What were the main changes associated with the instability of Antarctic ice sheets and was the production of Antartic Bottom Water (AABW) reduced or enhanced during these intervals? Was there also a potential influence of tectonic processes on the flow changes in the Agulhas region? Especially the closure of the Centarl American Seaway (CAS) in various phases between ~14 and ~2.7 Ma is thought to have had a profound impact on climate.

Changes in physical and chemical sediment properties in the Agulhas region are largely controlled by earth's orbital variations and allow a significant improvement of age models by cyclostratigraphy.

Another primary objective of our research is the detection and characterization of orbital and sub-orbital cycles in the Agulhas sedimentary environment in relation to paleoceanographic changes. The presence of orbital cycles in ocean sediments has widely been used to derive high resolution age models in Cenozoic sediments. Typically orbital chronologies are based on benthic oxygen isotope records ($\delta^{18}O$) that are correlated to astronomical forcing functions ("orbital tuning"). However, the generation of such records at high resolution over long time intervals is time consuming and will likely not be completed for the Exp. 361 sites over the next years. In the absence of $\delta^{18}O$ records cyclic changes in high resolution measurements of physical (e.g. density, colour reflectance, magnetic susceptibility) and chemical (major elements from XRF core scanning) parameters have been successfully used for orbital tuning. At the Exp. 361 Sites very regular cyclic amplitude changes are evident in the Pliocene sections (Gruetzner et al., 2017), but up to now have not been further investigated. Which orbital frequency do these cycles represent and how do the dominent frequencies change over time? What is the potential of the observed cycles for stratigraphic purposes? We will analyse those cyclicities in the depth and time domain and strive to generate orbitally tuned time series of sediment provenance.

References:

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