

## **From Greenhouse to Icehouse; to There and Back Again - Results from Arctic Ocean Drilling**

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Rising atmospheric CO<sub>2</sub> concentrations (IPCC 2007) are pushing Earth towards new 'greenhouse' states, not witnessed for more than 20 million years. Earth system studies of the ancient greenhouse state of the planet, e.g., during the early Palaeogene (65-35 Ma) and/or Late Cretaceous (100-65 Ma) are therefore becoming increasingly important, and are prominent on the research agenda, as are studies of potential mechanisms underlying the transition to the lower CO<sub>2</sub> world of the Oligocene and Neogene, or Icehouse Earth.

The first-ever Arctic drilling (Arctic Coring Expedition, ACEX, aka IODP Expedition 302) provided unprecedented snapshots of Arctic climates during the greenhouse conditions, and greenhouse-icehouse transition, spanning the past ~56 Ma. During times of ultra-greenhouse conditions (i.e., the Eocene Thermal Maxima, ETM, 1 and 2), ~55-53 Ma ago, our dinocyst and TEX<sub>86</sub> ratios records show the Arctic to have been near tropical with temperatures soaring to 24 °C. Meanwhile, detailed studies of this event offshore SW Africa (ODP 208) showed the impact of high CO<sub>2</sub> in terms of ocean acidification and lysocline shoaling from ancient deep water, tropical settings, while dinoflagellate blooms were raging around the globe.

Perhaps even more surprising, at levels dated ~49 Ma, the ACEX cores yield stunning concentrations of remains of the freshwater fern *Azolla* suggesting that at least episodically, completely fresh surface water settings characterized the Arctic Basin. Marking the end of the warmest phase of the past 100 Ma, the *Azolla* event may prove to have been instrumental in the capturing of atmospheric CO<sub>2</sub>, paving the way for global cooling; a hypothesis currently tested by the 3-PhD Darwin *Azolla* project. While recording the past, ACEX results may be also taken to portray a possible, 'business as usual' future of Earth.