

Baltic Sea Paleoenvironment Expedition



In September 2013, the *Greatship Manisha* left Kiel, Germany, with 17 scientists from Expedition 347 Baltic Sea Paleoenvironment onboard to begin coring and logging operations at 9 sites offshore Denmark and Sweden. Led by Co-chief Scientists Thomas Andrén of the School of Natural Sciences, Technology and Environmental

Studies at Södertörn University, Sweden, and Bo Barker Jørgensen of the Center for Geomicrobiology at Aarhus University, Denmark, the offshore Science Party and ESO staff spent 50 days coring the sediments in six sub-basins of the Baltic Sea Basin. Situated in the heartland of past Scandinavian Ice Sheet advances and retreats the coring sites have been subject to repeated glaciations and preserve unique geological, microbiological and environmental archives. These records will enable investigation of the environmental history and microbiological evolution of the Baltic Sea region over the last 140,000 years, from the beginning of the Eemian interglacial through the Last Glacial Maximum to the present day.

Scientific goals

There are several expedition scientific objectives that fall under four main research themes:

1. Climate and sea-level dynamics of marine isotope Stage (MIS) 5, including onsets and terminations;
2. Complexities of the last glacial, MIS 4-MIS 2;
3. Glacial and Holocene (MIS 2-MIS 1) climate forcing;
4. Deep biosphere in Baltic Sea Basin (BSB) sediments.

The expedition set out to recover sediment sequences spanning the time period from MIS 5 to the present day at the highest possible resolution. In order to meet this aim, nine sites were drilled during the expedition. The geographic distribution of the sites aimed to register the in- and out-flows from the Baltic Sea Basin, as well as the sediments deposited within the basin itself.

Dates: September 12 - November 1, 2013

Platform: *Greatship Manisha*

Deepest hole: 229.6 m

Number of boreholes: 30

Number of cores: 798

Core recovery: 1622.76 m (91.45%)

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Climate, sea-level and ice-sheet change

It is envisaged that the transect of drilled sites, from west to north east and from south to north, in this repeatedly glaciated and environmentally dynamic region will provide new scientific insights in a variety of research fields. Examples include regional and global issues on the timing and forcing



Greatship Manisha on station during Exp. 347..

of rapid climate and sea level changes; mechanisms behind hypoxia-driven processes in intracontinental sea basins, and reconstruction of the glacial history of the Scandinavian Ice Sheet and its interaction with the climate system. The palaeoenvironmental information will be relevant on a semi-continental scale, due to the fact that the Baltic Sea drains an area four times its size.

Biogeochemical Processes

The drilled sites will also give new insight into the controlling mechanisms for prokaryotic communities and underlying biogeochemical processes in the seabed. New data will show how the highly variable environment has affected the phylogenetic diversity of the microbial communities and which biogeochemical processes predominate today in the deep glacial and interglacial deposits.

Scientific results

During the 50-day long offshore phase aboard the *Greatship Manisha* and the Onshore Science Party held at the Bremen Core Repository in February-March 2014 (*right*), the scientists analysed the cores to gain a deeper understanding of the palaeoenvironmental evolution of the Baltic Sea Basin through the last glacial cycle.

The lowermost part of the cored sequences taken in the Little Belt and near Anholt Island revealed biostratigraphic indications of possible MIS 5 age, and sufficient material was collected to perform optically stimulated luminescence dating. Further laboratory investigations and dating are required, but it is likely that a deeper understanding of MIS 5 will be forthcoming. Also, material from these sites and others in Hanö Bay and Bornholm Basin are expected to provide information on conditions within the Baltic Sea Basin during parts of MIS 4-MIS 2.



The Expedition Team at the Onshore Science Party in Bremen.

of climate response and other external forcing mechanisms, and new knowledge on how the anthropogenically unaffected ecosystem responded. The Holocene sequence from the Landsort Deep is laminated and may allow us to reconstruct annual-scale environmental changes during the last c. 8000 years.

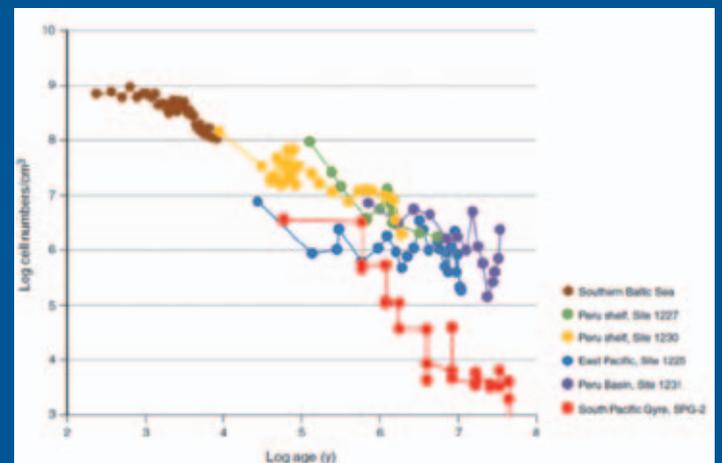
Four sites in the Little Belt, near Anholt Island, Landsort Deep and Bornholm Basin were selected for the study of the deep biosphere and how the buried microbial communities responded to major shifts in the Baltic Sea environment in the past and to varying lithologies and geochemical stratification in the present. Microbial cell counts are generally extremely high, particularly in the organic-rich Holocene deposits younger than ~8000 y that yielded the highest microbial abundances yet recorded by IODP (*below*). Samples were taken offshore for microbiological analysis from dedicated holes, and were shipped during and after the expedition to laboratories around the world and, based on the many novel ideas and techniques that will be applied, important new information on microbial life in the deep biosphere is expected.

| Site M0065 Hole, Bornholm Basin | | | | |
|--|---|--|--|--|
| Unit I | Unit II | Unit IIIa | Unit IIIb | Unit IIIc |
| Dark greenish gray, weakly laminated organic-rich clay, intervals of black bands with sharp bases, very well sorted. | Gray to dark gray laminated clay, minor organic content, iron sulphide-rich lamina. | Grayish brown weakly laminated clay, few silt laminae, clay intraclasts. | Dark gray, weak colour banding, very well sorted. | Grayish brown silty clay, parallel lamination, coarsening to base. |
|  |  |  |  |  |
| Marine depositional environment with mostly oxic conditions, with initial anoxic phases near base of unit. | Lacustrine depositional environment | Glacial lacustrine depositional environment, slumping events. | | |

Line scan image examples of core sections from Site M0065, Bornholm Basin

The glacial sequences recovered in the Landsort Deep, Hanö Bay and Bornholm Basin (*above*) will greatly improve knowledge of the deglaciation of the southern and central Baltic Sea Basin and will provide new general understanding of the behaviour of the Scandinavian Ice Sheet during MIS 2. The sequences from Little Belt and near Anholt Island may also contribute to this knowledge. The cored sequences from the Ångermanälven River estuary will give new insights into the late Holocene history of the northern part of the Baltic Sea Basin.

An unexpected long Holocene sequence from the Little Belt, together with an extremely expanded Holocene sequence from Landsort Deep, will allow high resolution reconstructions



Distribution of microbial cells in the seabed. The double-logarithmic plot shows examples of cell numbers per cubic centimeter and how these decrease with the age of the sediment. Cell counts from the Baltic Sea, 108–109 cells/cm³, are compared to data from the Pacific Ocean where counts drop below 10⁴ cells/cm³ in the oldest sediments of the most nutrient poor area, the South Pacific Gyre. Data compiled from the Baltic Sea (B. Cragg and R.J. Parkes, unpubl. data not from Exp. 347), Ocean Drilling Program sites (D'Hondt et al., 2003), and the South Pacific Gyre (D'Hondt et al., 2009). Modified from Jørgensen (2012).

For further reading

- Andrén, T., Jørgensen, B.B., and Cotterill, C., 2012. Baltic Sea Basin Paleoenvironment: paleoenvironmental evolution of the Baltic Sea Basin through the last glacial cycle. IODP Sci. Prosp., 347. doi:10.2204/iodp.sp.347.2012
- Jørgensen, B.B., 2012. Shrinking majority of the deep biosphere. PNAS, 109, 40, 15976–15977, doi: 10.1073/pnas.1213639109
- D'Hondt, S. et al, 2004. Distributions of microbial activities in deep seafloor sediments. Science, 306(5705):2216–2221. doi:10.1126/science.1101155