The evaluation of Computed Tomography hard- and software tools for micropaleontologic studies on foraminifera

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Foraminifera (Forams) are single-celled amoeba-like organisms in the sea, which build a tiny calcareous multi-chambered shell for protection. Their enormous abundance, great variation of shape through time and their presence in all marine deposits made these tiny microfossils the oil companies' best friend by facilitating the detection of new oil wells. Besides the success of forams in the oil and gas industry, they are also a most powerful tool for reconstructing climate change in the past.

The shell of a foraminifer is a tiny gold mine of information both geometrical as chemical. However, until recently the best information on this architecture was only obtained through imaging the outside of a shell with Scanning Electron Microscopy (SEM), giving no clues towards internal structures other than single snapshots through breaking a specimen apart. With X-ray computed tomography (CT) it is possible to overcome this problem and uncover a huge amount of geometrical information without destructing the samples. Using the last generation of micro-CT's, called nano-CT, because of the sub-micron resolution, it is now possible to perform adequate imaging even on these tiny samples without needing huge facilities.

In this research, a comparison is made between different X-ray sources and X-ray detectors and the resulting image resolution. Both sharpness, noise and contrast are very important parameters that will have important effects on the accuracy of the results and on the speed of data-processing.

Combining this tomography technique with specific image processing software, called segmentation, it is possible to obtain a 3D virtual representation of the entire forams shell. This 3D virtual object can then be used for many purposes, from which automatic measurement of the chambers size is one of the most important ones.

The segmentation process is a combination of several algorithms that are often used in CT evaluation, in this work an evaluation of those algorithms is presented. Difficulties arising when the forams shell is filled with material but it still remains possible to perform adequate segmentation.

The void inside the shell corresponds to the chambers of the foram and the inter-chamber connections. Using automatic separation algorithms it is possible to obtain the shape of individual chambers.

The results from the segmentation process can then be used to perform a multitude of analysis on each foram. Out of the shells geometry one can derive variations in shell thickness, shell density and shell porosity. Since the geometry of each individual chamber can be derived, it is possible to track chamber size variation for one foram or between two different forams, the difference in orientation and distance between the chambers.

In this work the algorithms and procedures have been applied on two forams:

1. *Pseudouvigerina sp.*, a benthic foram that lived within the sediments at the seafloor. It dates from the earliest Paleocene, 65 Ma and was collected near Brazos River, Texas.

2. *Globigerinoides*, a modern planktic foram, living in the upper part of the water comlumn in the open ocean. The test settled on the seafloor after death and was recently collected from the seafloor at 2900 m water depth at Nazca Ridge in the eastern Pacific Ocean.

It was found that foram A consists of 15 chambers with a total volume of 1.8 x 106 μm^3 and shows progressive growth of consecutive chambers (average of 1,5 magnification). After the large globular initial chamber, which indicates asexual reproduction, each chamber is slightly larger than the previous one. In the later stages the chambers develop lateral edges with a thickened margin, leading to a distinct triangular shape in cross section.

Foram B on the other hand has a distinct trochospiral coil (like a snail), consisting of 16 chambers with a total volume of 91 x 106 μm^3. The entire shell thickens with every successive chamber, so that the initial part of the test is embraced in a thick calcite crust. The chambers grow rapidly in size (average magnification of 2,24), which is typical for most planktic foraminifera. The globular shape aids in the buoyancy of the specimen for its planktic way of life.