Oxygen isotopes in conodonts from Baltica as indicators of Ordovician climate change

Studies of ancient ocean-atmosphere composition and climate conditions are needed to understand the way Earth has changed over time in order to predict the future global changes. From this perspective critical attention must be given to Ordovician (487–443 million years ago), a period which witnessed a rapid diversification of sea life. This project aims at application of the oxygen isotope compositions of single conodont species in order to enrich knowledge on climate changes which took place during that particular period.

Ancient temperature estimates are mainly based on oxygen isotope analyses ($\delta^{18}O$) of carbonate rocks with fossils such as brachiopods (composed of calcium carbonate) and conodonts (composed of calcium phosphate). Regardless of the recent progress in studies on Ordovician climate, many open questions remain, and the global $\delta^{18}O$ datasets have significant gaps both in time and space. This limits our understanding of crucial transitions in Earth's history from the hot Cambrian greenhouse conditions to the late Ordovician ice age.

We will investigate conodont elements, which are mm-size tooth-like structures of eel-like animals that lived in a shelf sea. The specimens will include different conodont species from Baltica – one of the ancient continents, which hosted an extensive epicontinental sea, the Baltic Palaeobasin. They will be obtained from existing and well-documented collections from Estonia and Latvia. Study of oxygen isotope compositions of different conodont species should allow us to reconstruct the climate change through the Ordovician. First, we will investigate whether conodonts from Baltica were resistant to secondary alteration, and therefore, are reliable source of information for paleoclimate study. For this purpose, we will characterize chemical and structural compositions of the conodont elements using several analytical methods: Raman and infrared spectroscopy as well as electron probe microanalysis and laser ablation ICP mass spectrometry. The outcome of this characterization work will not only yield the context information for the interpretation of isotope data for conodonts from Baltica, but will also provide methodological guidelines relevant to numerous other paleoenvironmental studies of bioapatite.

Most previous research devoted to $\delta^{18}O$ composition of conodonts has been conducted using bulk method (GS-IRMS) that requires pooling many dozens of conodont elements for a single measurement. As such, the bulk method does not allow to study conodont-poor samples containing just few specimens and to address $\delta^{18}O$ variability between different conodont species and within individual elements. On the other hand, such research may be conducted with the help of *in situ* secondary ion mass spectrometry (SIMS) analyses.

Results of our pilot $\delta^{18}O$ study of conodonts showed that SIMS data acquired on single-species samples deviate from bulk data inherently performed on multi-species assemblages. Therefore, the key objective in this project is to reconstruct climate change throughout Ordovician based on isotope compositions of different conodont species. We plan to examine samples from two drill cores in NE Estonia in order to reconstruct climate fluctuations and trends over a period of *ca.* 20 million years.

Additionally, we will investigate whether the offsets in $\delta^{18}O$ values between individual species reflect preferred habitats within a water column with a temperature gradient and whether the offsets vary depending on changes in water depth. This portion of our study will be conducted on samples from sediment successions corresponding to the shallower, intermediate, and deeper shelf parts of the Eastern Baltic Basin (four drill cores in Estonia and Latvia).

Several studies have reported inconsistencies between SIMS and GS-IRMS $\delta^{18}O$ data for the same research material. We aim at solving this controversy and will establish the analytical recipe for conodont isotope analysis by SIMS to produce representative results free of analytical artifacts. This study will, for the first time, conduct combined SIMS-EBSD (electron backscattered diffraction) analyses to assess the influence of the crystallographic orientation of conodonts on $\delta^{18}O$ data.