CASE STUDY No. 30658

Early Earth Sciences at the University of Göttingen

Earth Sciences at the Geoscience Center Göttingen

The Geoscience Center Göttingen (GZG) is an interdisciplinary focused research institute of the Georg-August-University of Göttingen in Germany. International teams of overall more than 150 scientists are working towards a better understanding of geologic processes that shaped our planet Earth throughout its history, and will shape it in the future (e.g. [1]).

Formation and evolution of the early Earth

When the Earth formed about 4.6 billion years ago, it looked very different than it does today: It was a "ball of molten rock" in space that was formed by collisions of numerous planetary bodies. Today there are continents, surrounded by oceans, providing the platforms for the origin of life. But how did the Earth evolve from a rather hostile environment to a habitable planet? The research group in Göttingen is trying to find the answers. Matthias' team studies the oldest rocks on Earth, to gain insights into the processes that occurred during Earth's early history (e.g. [1]). Especially isotope and elemental compositions can give useful clues on the chemical evolution and structure of the Earth's earliest mantle and crust.

Matthias Willbold is Professor of Isotope Geochemistry at the Geoscience Center of the University of Göttingen. The team around Matthias utilizes a variety of mass spectrometric techniques to implement new geoanalytical methods (e.g. [2]) and to shed light on planetary formation processes in the early solar system.

Extracting smallest isotope signatures from rocks

The researchers are interested in specific elements and isotopes within rocks that naturally occur in extremely low concentrations. In order to be able to measure these specific elements and their isotope composition, they need to be isolated from the rock matrix. This is done by chemical separation. First of all rocks get crushed and dissolved in strong acids. The resulting solutions contain the complete element inventory of the rock sample. They are processed through ion exchange columns in order to separate the elements and isotopes of interest. The column chemistry must be done in ultra clean laboratories to avoid any contamination. The abundances of the separated species are eventually analyzed in a mass spectrometer.

Geochronology and the timing of geological processes during Earth's history

One of the major applications within Matthias' research group is age dating of rocks. These age data are obtained from rare radiogenic isotopes that act as a natural chronometer. Highly precise ratios of these isotopes enable accurate constraints on when rocks were formed as well as when and how certain geological processes on Earth took place (e.g. [3], [4]). Such processes include e.g. subduction zones processes, where Earth's continental or oceanic crust are being subducted or transferred back into the mantle. Another important process is mantle convection that can be regarded as a mixer for different mantle reservoirs on a long-term scale.

All these processes not only occur today, but have also occurred on the early Earth in similar forms, leaving their mark in the isotopic ratios. Comparing the isotopic signatures from then and today is a powerful strategy to a better understanding of the evolution of our planet Earth.

Figure 1: Thermo Scientific™ Neptune™ Series MC-ICP-MS

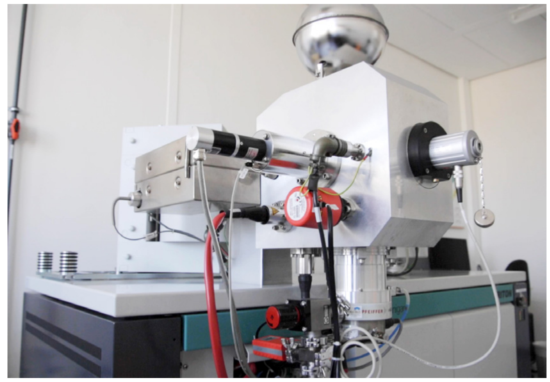

Figure 2: Thermo Scientific™ Triton™ Series TIMS

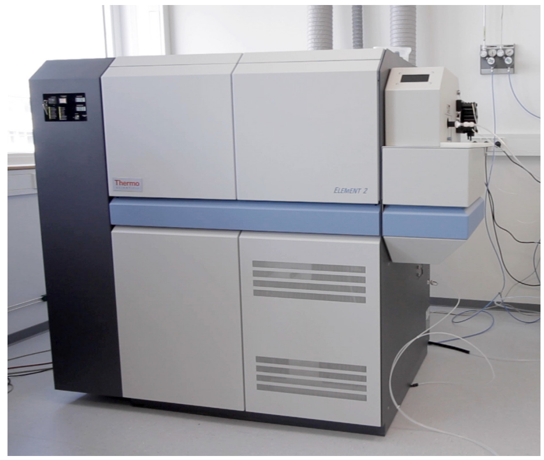

Figure 3: Thermo Scientific™ Element™ Series HR-ICP-MS

Figure 4: Thermo Scientific™ iCAP™ Q ICP-MS

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Instruments in the lab

To tackle their scientific questions, Matthias Willbold's team employs a wide range of mass spectrometers. For high precision isotope ratio analysis of elements across the periodic table, the team uses the Thermo Scientific™ Neptune™ Series MC-ICP-MS and the Thermo Scientific™ Triton™ Series Thermal Ionization Mass Spectrometer. Besides, the scientists utilize the Thermo Scientific™ iCAP™ Q ICP-MS and the Thermo Scientific™ Element™ Series HR-ICP-MS, both providing concentration data at very high accuracy and precision.

References

1. Willbold, M., Elliott, T.R., Moorbath, S. (2011). The tungsten isotopic composition of the Earth's mantle before the terminal bombardment. Nature, 477, 195-198, DOI:10.1038/nature10399.
2. Willbold, M., Hibbert, K., Lai, Y.-J., Freymuth, H., Hin, R.C., Coath, C., Vils, F., Elliott, T., 2016. High-Precision Mass-Dependent Molybdenum Isotope Variations in Magmatic Rocks Determined by Double-Spike MC-ICP-MS. Geostandards and Geoanalytical Research, 40, 389-403. DOI: 10.1111/j.1751-908X.2015.00388
3. Willbold, M., Stracke, A. (2010). Formation of enriched mantle components by recycling of upper and lower continental crust. Chemical Geology, 276 (3-4), 188-197, DOI: 10.1016/j.chemgeo.2010.06.005.
4. Willbold, M., Hegner, E., Stracke, A., Rocholl, A. (2009). Continental geochemical signatures in dacites from Iceland and implications for models of early Archaean crust formation. Earth and Planetary Science Letters, 279 (1-2), 44-52, DOI: 10.1016/j.epsl.2008.12.029.

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