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CASE STUDY

No. 30659

Unraveling the geologic history of meteorites and our planet Earth

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.

Characterization of extraterrestrial materials

Andreas Pack's team determines the triple oxygen isotope signatures ($\delta^{18}O$, $\delta^{17}O$) in meteorites coming from planetary bodies far away in the solar system, including meteorites originating from Mars and the Moon. By studying the oxygen isotope characteristics of these meteorites, they can not only identify their origin and characterize their parent bodies. But they can also draw conclusions on the otherwisely difficult to access Earth's upper atmosphere the meteorites passed through during their fall towards the Earth's surface (e.g. [1]).

Reconstruction of paleotemperature

Andreas Pack's group develops a novel application to determine the paleotemperature of the Earth's earliest oceans. They analyze the triple oxygen isotope composition ($\delta^{18}O$, $\delta^{17}O$) of carbonate rocks that have been precipitated from Precambrian seawater, to derive the ocean temperature more than 1 billion years ago. Apart from that they utilize "classical" combined carbon and

Andreas Pack is a professor for isotope geology at the University of Göttingen. His research focuses on high precision measurements of oxygen isotope ratios in silicate and carbonate rocks and minerals, and in water samples. The team around Pack utilizes the obtained data to understand formation processes in the early solar system, and to characterize the evolution of atmospheric CO_2 throughout Earth's history.

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oxygen isotopes ($\delta^{18}O$, $\delta^{13}C$) of more recent carbonates, and triple oxygen isotope systematics of silicates to draw conclusions on past environmental conditions (e.g. [2]).

Determination of paleo-CO_2 concentrations

The scientists around Pack investigate the oxygen isotope composition of fossil bioapatite to draw conclusions on paleo-CO_2 concentrations (e.g. [3]). Coupling of CO_2 concentrations in the atmosphere and global temperature is more than ever a hot topic, due to the man-made emissions of CO_2. A better understanding of this coupling on the long, million or billion years, perspective serves as a ground proof for predictions that are now made for the future.

Instruments in the lab

A total of three different gas source mass spectrometers is installed in Andreas Pack's lab, each of which is dedicated to obtain the specific isotope measurements for the different applications:

1. 10 kV IRMS: The Thermo Scientific™ MAT 253™ 10 kV IRMS is utilized for high precision measurements of the three different isotopes of O_2, as extracted from silicates, bioapatite, and water ($\delta^{18}O$, $\delta^{17}O$).

2. IRMS with Carbonate Device: For the measurement of classical carbon and oxygen isotope composition ($\delta^{18}O$, $\delta^{13}C$) of carbonates, they use the Thermo Scientific™ Kiel IV™ Carbonate Device in combination with the Thermo Scientific™ Delta™ Series IRMS.

Figure 1: MAT 253 Plus 10 kV IRMS

3. High Resolution IRMS: They use a Thermo Scientific™ Ultra™ High Resolution Gas Source Mass Spectrometer for highly precise triple oxygen isotope measurements ($\delta^{18}O$, $\delta^{17}O$) on CO_2. This instrument can resolve isobaric interferences, such as ^{16}OH from ^{17}O and $H_2{}^{16}O$ from ^{18}O. As a result, direct measurements of the oxygen fragments in CO_2 can be applied, without any further preparation of the samples.

Figure 2: Delta V IRMS

Figure 3: Ultra HR-IRMS

References

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2. Herwartz, D., Pack, A., Krylov, D., Xiao, Y., Muehlenbachs, K., Sengupta, S., Di Rocco, T. (2015) Revealing the climate of snowball Earth from Δ17O systematics of hydrothermal rocks, Proc. Nat. Ac. Sci. 112 5337-5341.
3. Gehler, A., Tütken, T., and Pack, A., 2012. Oxygen and Carbon Isotope Variations in a Modern Rodent Community—Implications for Palaeoenvironmental Reconstructions. PlosONE 7, e49531. doi:10.1371/journal.pone.0049531.
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