Developing a high temperature magnetometer to study oceanic basalt magnetisation carriers

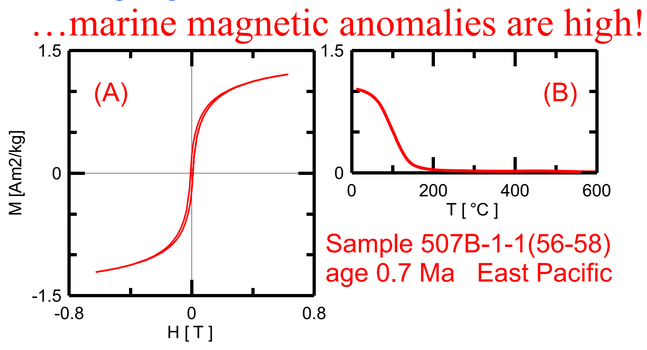
Michael Wack, Maxim Alexutin and Jürgen Matzka
Department of Earth and Environmental Sciences, University Munich
Theresienstr. 41, 80333 Munich, MichaelWack@gmx.net

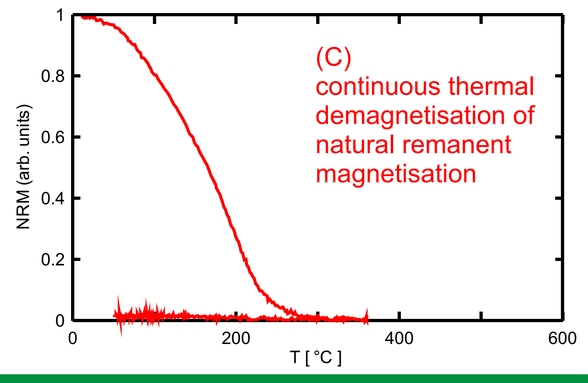
Why is oceanic basalt such a peculiar magnetisation carrier and what relevance has continuous thermal demagnetisation?

At the mid-ocean ridge...

The magnetic mineral of the ocean basalt is a quenched titanomagnetite which gives rise to a strong spontaneous magnetisation (A) and has a Curie-temperature of around 150 °C (B). This mineral is the carrier of the natural remanent magnetisation (NRM), as can be demonstrated by continuous thermal demagnetisation (C), which shows a similar unblocking temperature around 250 °C.

…marine magnetic anomalies are high!

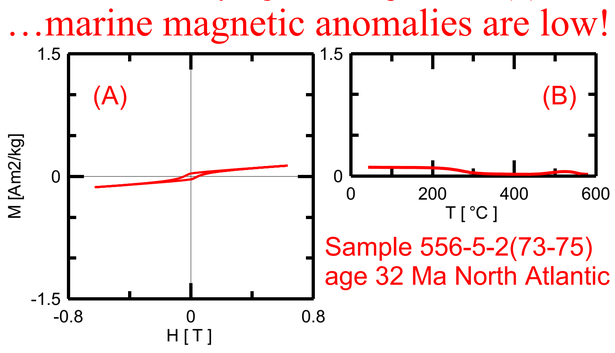


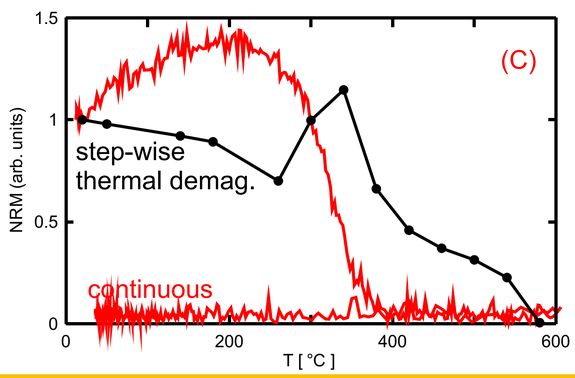


In 10 to 40 Ma old oceanic crust...

The original titanomagnetite is substituted by its low-temperature oxidation product titanomaghemite with a lower magnetisation (A) and a higher Curie-temperature of around 300 °C (B). Here, titanomaghemite is the carrier of the NRM, as can be demonstrated by continuous thermal demagnetisation, which shows an unblocking temperature around 380 °C, but not by stepwise demagnetization (C).

…marine magnetic anomalies are low!

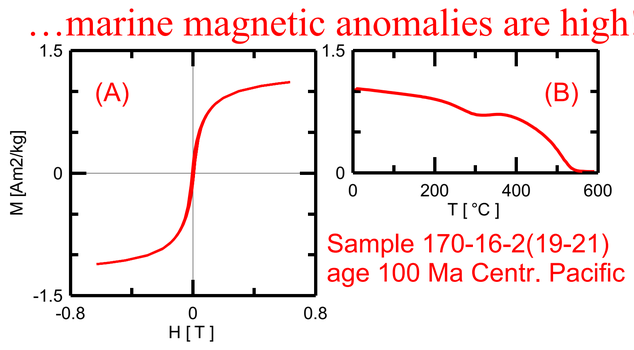


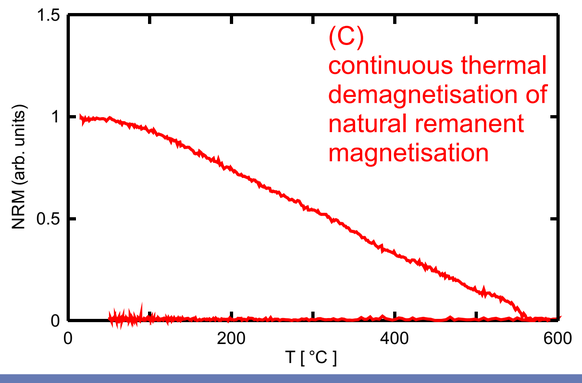


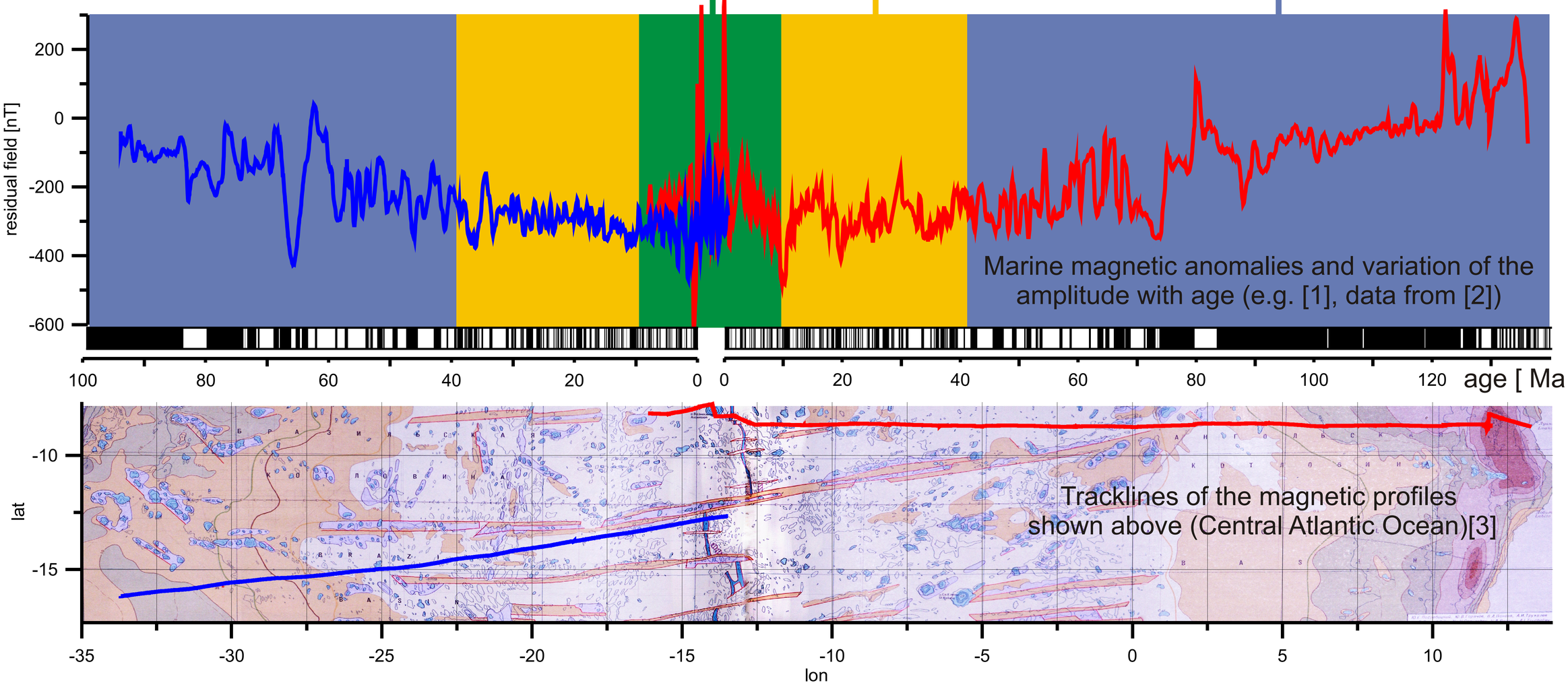
In > 40 Ma old oceanic crust...

another magnetomineralogical change has occurred. Samples are strongly magnetic (A) and have one or two high Curie-temperatures (B). Probably magnetite is the carrier of the NRM, as can be demonstrated by continuous thermal demagnetisation (C), which shows an unblocking temperature around 580 °C.

…marine magnetic anomalies are high!

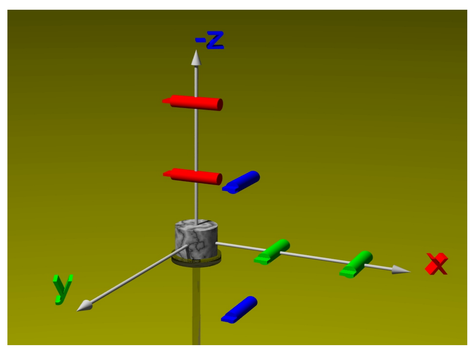




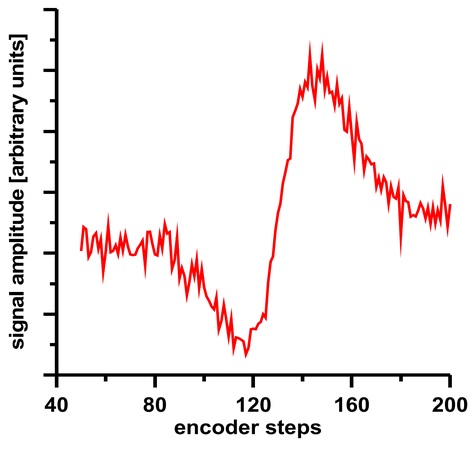


The “Hotspin 2” - developing an instrument for continuous thermal demagnetisation of the NRM of rock samples

Sensors & Sensitivity

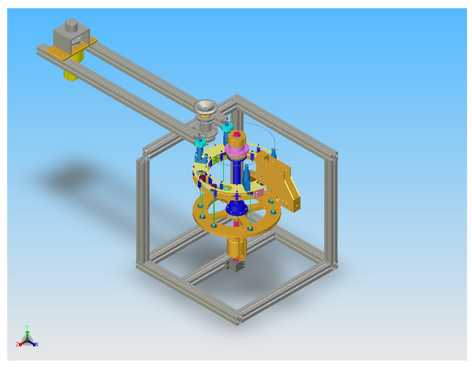


Sensor arrangement of Hotspin 2. The magnetic sensors are fixed in space, the specimen (cylinder) is moving on a circular path in the y-x-plane.

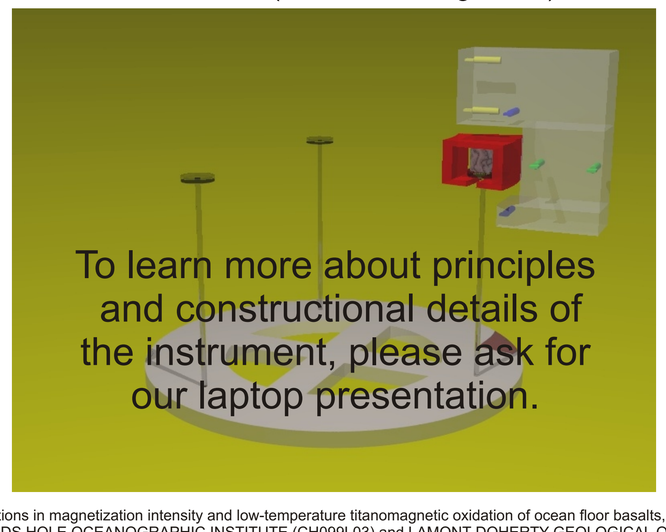


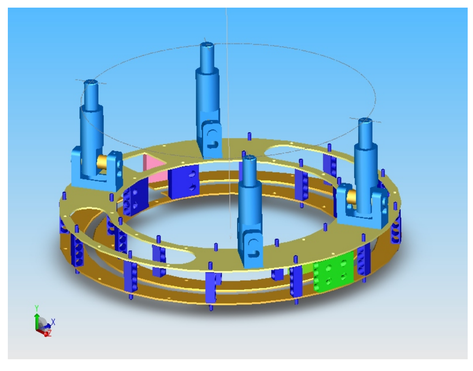
Magnetic signal (z-component) of sample AGA9_2 with a magnetization of 55 mA/m measured by Hotspin 2. The noise level is in the order of 10 mA/m.

Heating

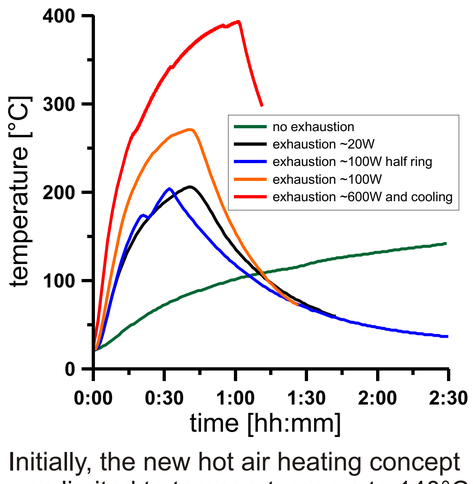


The Hotspin 2 spinner magnetometer is enclosed by three Helmholtz coils (photo on the left side) to generate a field free environment for the demagnetisation process. Main mechanical features are the rotating sample platform below the circular oven and the sensor holder (sketch on the right side).





The oven encloses the circular sample track and is completely non-magnetic. Hot air is guided through copper pipes which heat the samples by radiation.



Initially, the new hot air heating concept was limited to temperatures up to 140°C (green). After improving the air circulation, 400°C can now be achieved (red).

References:
[1] U. Bleil, N. Petersen, Variations in magnetization intensity and low-temperature titanomagnetic oxidation of ocean floor basalts, Nature 301 (1983) 384-388.
[2] profiles measured by WOODS HOLE OCEANOGRAPHIC INSTITUTE (CH099L03) and LAMONT-DOHERTY GEOLOGICAL OBSERVATORY (C1604) provided by National Geophysical Data Center (NGDC).
[3] International Geological-Geophysical Atlas of the Atlantic Ocean. Udintsev G.B.(ed). IOC (of UNESCO), Min.Geol.USSR, Ac.Sci. USSR, Moscow, 1989-1990.