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Building Physical Models of the Distribution of Iron-oxides in Basalts: *'How MMT deals with MicroCT resolution limitations'*

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Micromagnetic tomography (MMT) is a new promising paleomagnetic technique that obtains magnetic moments for individual iron-oxides. These magnetic moments are inferred from surface magnetometry data obtained with quantum diamond microscopy (QDM), and iron-oxide positions determined with micro X-Ray computed tomography (MicroCT). Different to classical techniques, MMT does not depend on bulk measurements of samples. This makes it possible to only select the most reliable magnetic recorders. To make this improvement possible, MMT first has to deal with the presence of undetected magnetic carriers in basaltic rock samples used in previous MMT studies. Although particles smaller than 1 µm are good recorders of the magnetic field and may be visible in surface magnetometry, they are not detected by MicroCT. This violates one of the foundations of MMT and may disturb magnetic moments of other detected grains. However, it is currently unknown how many of these small disturbing particles are present in Hawaiian basaltic samples. We know that the smallest disturbing grains have a diameter of around 40 nm, since particles smaller than this threshold become superparamagnetic and cannot store magnetic signals. For this reason we want to obtain a grain-size distribution for iron-oxides from 20 nm to 10 µm to cover the complete range of grains that are capable of storing Earth's magnetic field. This requires a combination of FIBSEM slice-and-view and MicroCT techniques; FIBSEM detects single and pseudo-single domain grains with sizes between 20 nm and 1 µm and MicroCT detects multi-domain grains with sizes larger than 1 µm. Subsequently, FIBSEM and MicroCT data are combined to obtain the full spectrum of grain sizes. Unfortunately, grains are not uniformly distributed in the samples, so a scaling by volume would not produce a realistic spectrum. Therefore, based on observations that iron-oxides grains cluster on the interfaces of other minerals, we calculated how many times FIBSEM mineral interfaces from FIBSEM data fit the mineral interfaces from MicroCT data. Then, this factor is used to scale the FIBSEM iron-oxides to MicroCT iron-oxides and to obtain a complete distribution of all grain sizes. Interestingly, this distribution shows a clear peak in grain size at 70-80 nm. Furthermore, the smallest grain fraction is fitted a lognormal trend, but the fraction larger than 0.18 µm are fitted an exponential decay trend. With these trendlines in place we have finally acquired a realistic set of boundary conditions for the distribution of iron-oxide particles in basaltic rocks. This enables us to populate models with a realistic distribution of particles, which ultimately may shed light on the disturbing presence of small iron-oxides in MMT results. If we know the effect of these disturbances, we will understand which grains MMT can solve with highest certainty, ultimately leading to paleomagnetic interpretations on grain scale.