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Towards an understanding of magnetic mineralogy in speleothems from South America

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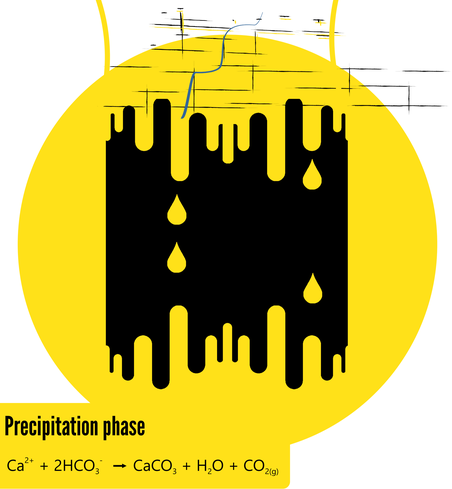
Dissolution phase

$H_2O + CO_2 \leftrightarrow H_2CO_3$

$CaCO_3 + H_2CO_3 \leftrightarrow Ca^{2+} + 2HCO_3^-$



Precipitation phase

$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + H_2O + CO_{2(g)}$

1 What does speleothem magnetism record in (sub)-tropical sites?

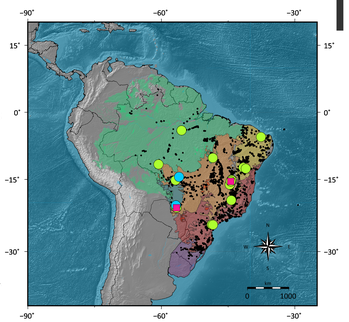
- The magnetic signal in speleothems has been used to document geomagnetic behavior and to constrain soil dynamics, paleoflood and paleorainfall cyclicity.
- The resolution of magnetic speleothem records provides information on processes operating at annual to millennia scales.
- Oxygen and carbon isotopes are the main proxies used for comparison with the magnetic signal, being mostly related to paleoprecipitation and changes in vegetation cover. However, these proxies provide little information on other processes that control magnetic mineral formation and recycling, such as soil formation, magnetic enhancement and limestone weathering.
- Here we present a comprehensive speleothem magnetism database from different biomes and climate (latitudinal variation) over South America.
- 139 specimens from different stalagmites, limestone and soil were used. This database aims to understand how the rock magnetic properties relate to the different environments (climates and biomes).

Speleothem database:

22 caves - 90 specimens

2 limestones - 15 specimens

4 soil - 34 specimens



Caves

- All caves registered
- Caves sampled
- Cave and soil sampled
- Caves with samples from stalagmite, soil and limestone

Brazilian Biomes

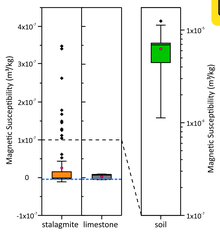
- Amazon (Tropical and Subtropical Forests)
- Caatinga (Deserts and Xeric Shrublands)
- Cerrado (Tropical and Subtropical Grasslands, Savannas and Shrublands)
- Pantanal (Flooded Grasslands and Savannas)
- Atlantic Forest (Tropical and Subtropical Moist Forests)
- Pampa (Tropical and Subtropical Grasslands, Savannas and Shrublands)

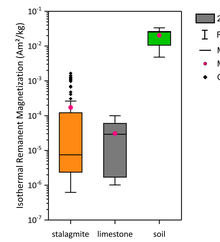
2 Magnetic methods | Results

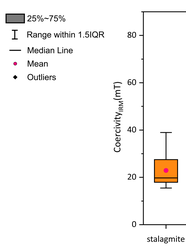
Rockmag methods:

- Magnetic susceptibility (m³/kg)
- Isothermal remanent magnetization (IRM) (Am²/kg)
- S-ratio (0.5*(IRM@1T-IRM@0.3T)/IRM@1T) - for low-coercivity minerals content
- Stepwise alternating field (AF) (77 steps) after IRM@1T
- Unmixing of magnetic coercivity distribution through skewed generalized Gaussian functions (MAXUnMix, Maxbauer et al., 2016)
- Comparison with literature through Egli's diagram (Median Destructive Field vs Dispersion parameter)

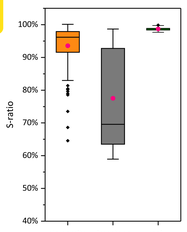
Concentration Parameters

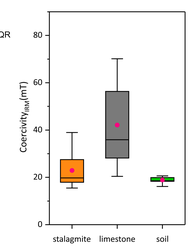


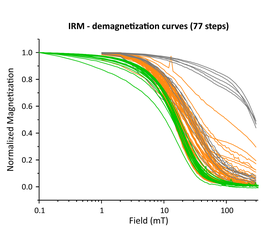


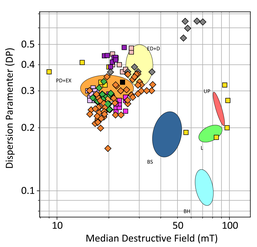


Magnetic subpopulation identification







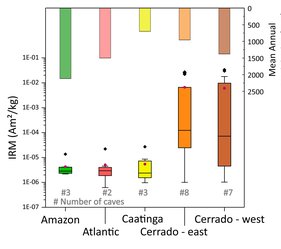


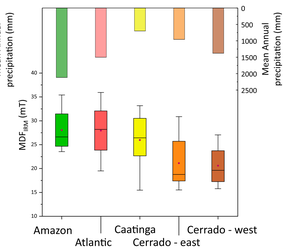
Egli's database
- Eolian Dust + Detrital
- Pedogenic + Extracelular magnetite
- Biogenic Soft
- Biogenic Hard
- Urban Pollution
- Loess

Speleothem magnetism studies
- Bourne et al. (2015)
- Font et al. (2014)
- Jaqueto et al. (2016)
- Lascu and Feinberg (2011)
- Osete et al. (2012)
- Zhu et al. (2017)
- Stalagmite - This study - IRM
- Limestone - This study - IRM
- Soil - This study - IRM

3 Discussion | Summary

- Rock magnetic properties show that ferromagnetic minerals are present in all stalagmites, including the "cleanest" ones used for 230Th dating.
- Concentration parameters in stalagmites show low values of magnetization and magnetic susceptibility when compared to overlying soils, reflecting the dilution effect of their calcite matrix.
- The coercivity distributions within speleothems suggest that soils are the primary contributor of magnetic minerals as defined by the coercivity spectra (~20 mT) (IRM unmix, Egli's diagram) and S-ratios.
- There is not a simple relationship between the mean annual precipitation above a cave and the concentration of magnetic material within a speleothem. Biomes characterized by higher precipitation (Amazon and Atlantic) with high soil moisture provide low amounts of pedogenic minerals to be transported into the cave system.
- Biomes with lower precipitation (Caatinga) form very thin soil layers and as a consequence, provide low amounts of magnetic minerals to the cave system.
- The Cerrado biome (Savanna like) shows the highest concentration of magnetic grains and the lower coercivity values. This is probably related to the strong seasonality and magnetic enhancement in the overlying soils.





Magnetic properties | Biome

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