Classification of Antarctic meteorites by magnetic susceptibility

Vinciane Debaille[1], Jérôme Gataccecca[2], Pierre Rochette[2], Hamed Pourkhorsandi[2], Matthias Van Ginneken[1,3,4], Thierry Leduc[3], Marleen De Ceukelaire[3], Steven Goderis[4], Philippe Claeys[4]

[1]*Laboratoire G-Time, Université Libre de Bruxelles, Brussels, Belgium*

[2]*CEREGE, Université Aix-Marseille, Aix-en-Provence, France*

[3]*Royal Belgian Institute of Natural Science, Brussels, Belgium*

[4]*AMGC, Vrije Universiteit Brussel, Brussels, Belgium*

Meteorite classification is a primordial task usually done by combining petrography and chemical analyses, for example by measuring the Fa and Fs content in respectively olivine and low-Ca pyroxene. The instrument of choice for these chemical analyses is electron microprobe, but for equilibrated ordinary chondrites, the most numerous meteorites at the surface of the Earth, alternative techniques, cheaper or less time consuming, have been proposed such as oil immersion or Raman spectroscopy (Pittarrelo et al., 2015). Because the oxidation state and the amount of metallic iron are highly variable in meteorites, studying their magnetic susceptibility can also be helpful to characterize meteorites (e.g. Rochette et al., 2003; Folco et al., 2006). In meteorites, the magnetic susceptibility is proportional to the amount of ferro-magnetic phases, essentially Fe-Ni metal, magnetite and pyrrhotite (Rochette et al., 2012). In ordinary chondrite, magnetite and pyrrhotite are absent so that magnetic susceptibility is a direct proxy to the Fe-Ni metal amount. An important caveat of that method is that terrestrial weathering can shift the magnetic susceptibility towards lower values (Rochette et al., 2003, 2012). Because of their preservation in a cold and dry environment, Antarctic meteorites are usually less altered than hot desert meteorites, and here we present a dataset newly obtained on Antarctic meteorites.

Magnetic susceptibility has been measured on the Antarctic meteorites collection at the Royal Belgian Institute for Natural Sciences. This collection is the Belgian share of the Japanese-Belgian meteorites collected in 2009-2010, 2010-2011 and 2012-2013. The measurements have been made using a SM150 portable instrument from ZH instrument, and a SM30 instrument from the same company for samples larger than ~30 g (see Gattacceca et al. 2004).

The classification of ordinary chondrites in the H, L and LL groups according to their magnetic susceptibility shows good agreement with the classification previously obtained using electron microprobe analysis. The distribution of LL chondrites shows a wider range but clearly separated from L chondrites. Only minor shifts to lower values of magnetic susceptibility are observed for the Antarctic meteorites, in agreement with their limited alteration, making the magnetic classification method very powerful for this collection. The main divergence between chemical and magnetic susceptibility classification is observed for type 3 ordinary chondrites (4 over 14 samples). We propose that type 3 ordinary chondrites classification should be confirmed by several means because silicate composition is not always fully diagnostic for these unequilibrated rocks.

On the not-yet classified ordinary meteorites from the collection (187 samples), the magnetic susceptibility peaks for H, L, LL are also observed. In this population, H chondrites are two times more abundant than L chondrites, suggesting that their relative abundance could be biased by the existence one or several H chondrite showers.

In conclusion, classification by magnetic susceptibility is particularly well-adapted to Antarctic meteorites and can provide a fast and efficient way to classify ordinary chondrites, including the unequilibrated ones.

References

Folco L., Rochette P., Gattacceca J., Perchiazzi N.. In situ identification, pairing and classification of meteorites from Antarctica by magnetic methods. Meteoritics and Planetary Science 41, 343–353, 2006.

Gattacceca J., Eisenlohr P., Rochette P., Calibration of in-situ magnetic susceptibility measurements. Geophys.J. Int., 158, 42‑49, 2004.

Pittarello, L., Baert, K., Debaille, V., Claeys, Ph., Screening and classification of ordinary chondrites by Raman spectroscopy, Meteoritics & Planetary Science 50, 1718-1732, 2015.

Rochette P., Gattacceca J., Lewandowski M., Magnetic classification of meteorites and application to Soltmany fall. Meteorites 2, 67–71, 2012.

Rochette P., Sagnotti L., Bourot-Denise M., Consolmagno G., Folco L., Gattacceca J., Osete M.L., Pesonen L., Magnetic classification of stony meteorites: 1. Ordinary chondrites. Meteoritics & Planet. Sci. 38, 251‑268, 2003.