MAGNETIC SUSCEPTIBILITY AS A TOOL FOR ASTEROID EXPLORATION. T. Kohout[1, 2] and D. Britt[3], [1] Department of Physics, University of Helsinki, Finland (tomas.kohout@helsinki.fi), [2] Institute of Geology, Academy of Sciences, Prague, Czech Republic, [3] Department of Physics, University of Central Florida, USA.

Introduction: Magnetic susceptibility of a rock is dependent on concentration of ferromagnetic minerals. It is a common diagnostic parameter determined during physical properties studies of terrestrial as well as extraterrestrial rock samples (meteorites). Magnetic susceptibility proved to be reliable non-destructive tool in distinguishing various types of extraterrestrial materials (fig. 1) [1], [2], [3] and in searching for compositional variations of meteorite falls [4], [5].

Magnetic susceptibility of asteroids: We can build on the extensive database of magnetic susceptibility measurements of meteorites and use it as a diagnostic tool to characterize the mineralogy and identify the meteorite analogs of asteroids of various clans during rendezvous missions. There are three possible methods to determine asteroid magnetic susceptibility [6]:

In-situ susceptibility measurement of the asteroid surface. A simple susceptibility measurement coil can be incorporated into lander or surface drop probe. Its design can be similar to commercially available handheld susceptibility meters or to one described in [7] or [8]. Advantage of this method is that the contact measurement provides a reliable susceptibility measurement and the required instrumentation is simple and reliable. However, the penetration of the coil probe is limited to the top few centimeters of the surface and may not be representative for the whole asteroid.

Regolith on an airless body is subject to space weathering. This process is often associated with production of iron nanoparticles. These particles are often in super-paramagnetic state exhibiting high frequency dependence. In this case low penetration depth of surface coil is advantage as additional valuable information about regolith maturity can be extracted from frequency dependence of the magnetic susceptibility [8].

Susceptibility determination of the whole asteroid from interaction with solar wind. This approach requires a space probe with magnetometer to be inserted on asteroid orbit. The interplanetary magnetic field (IMF), especially during solar storms, may induce detectable magnetic fields around an asteroid which are directly proportional to asteroid magnetic susceptibility [6]. The main advantage is that the derived susceptibility represents bulk value of the whole asteroid. However, the measurement requires several subsequent orbits and the precision depends on knowledge of precise asteroid shape and IMF strength.

Susceptibility measurement of the sample return. Sample return delivered to the laboratory represents a great opportunity because it can be studied with same methods and instrumentation as meteorites or terrestrial samples are and thus the results can be directly compared. Additionally magnetic susceptibility can be compared with mineralogical and chemical analysis. However, any sample return is likely to be a rather small quantity of the asteroid's regolith so its representability for the whole asteroid must be considered with caution.

Conclusions: Magnetic susceptibility, together with other methods of spectral and mineralogical characterization, can provide diagnostic parameters to determine an asteroid mineralogy and meteorite analogue within various asteroid clans. All three above proposed methods of asteroid susceptibility determination have their advantages as well as limitations. The most reliable approach is a combination of bulk asteroid susceptibility determination from induced magnetization by IMF together with asteroid surface or sample return measurement. This approach allows us to study difference between composition of bulk asteroid and its surface. Additionally regolith maturity can be estimated from frequency dependence of asteroid surface susceptibility.

References:

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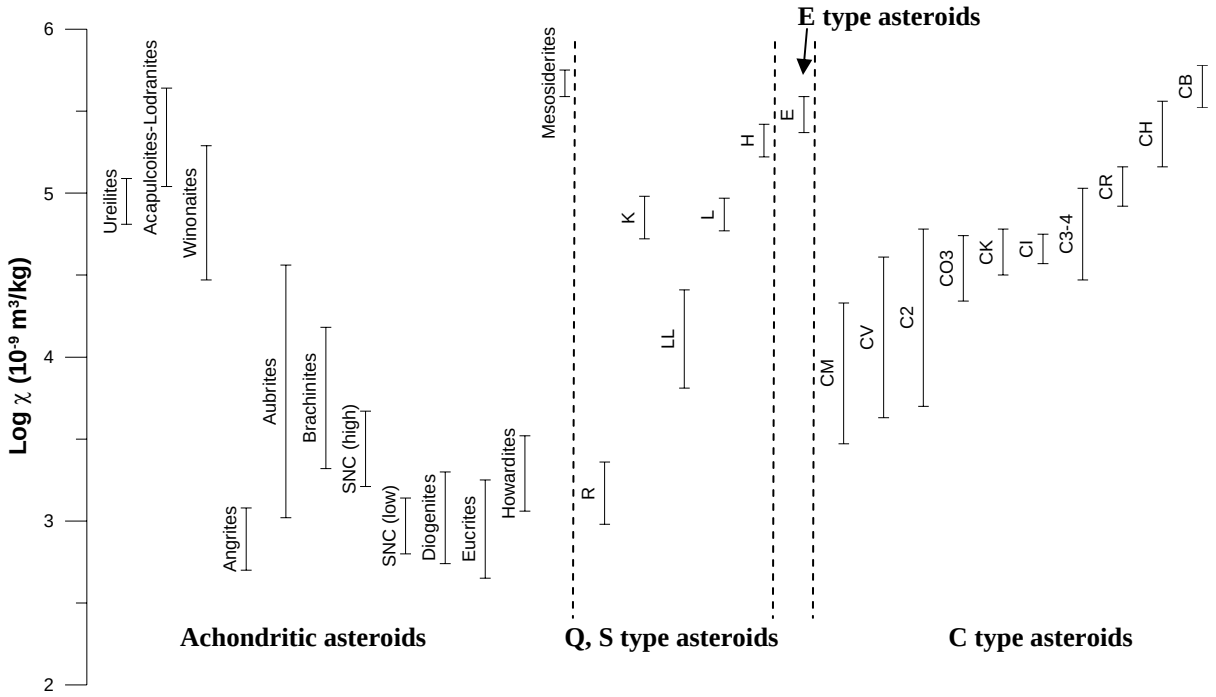

Fig 1. Magnetic susceptibility (logarithm) of basic asteroid clans similar to common meteorite types. Meteorite analogs can be determined from asteroid susceptibility in each clan. Meteorite susceptibility data are compiled from [1], [2] and [3].