Systematic detection of carbonaceous phases in chondrites – request for sophisticated techniques for Hayabusa 2 particle analyses

V.H. Hoffmann[1,2], T. Mikouchi[3], M. Kaliwoda[4], R. Hochleitner[4]

[1]*Fac. Geosciences, Dep. Geo- and Environmental Sciences, Univ. Munich,* [2]*Dep. Geosciences, Univ. Tübingen, Germany;* [3]*Dep. Earth Planet. Science, Univ. Tokyo, Japan;* [4]*Mineralogical State Collection, Munich, Germany.*

The Asteroid Explorer "Hayabusa 2" is the successor of "Hayabusa" (MUSES-C), which for the first time ever returned pristine samples from an asteroid [1]. 25143 "Itokawa" is a small Near-Earth S-type asteroid consisting mainly of ordinary chondrite type material [2, and refs herein]. The mission was a major step towards further elucidating the origin and formation of our solar system. The "Hayabusa 2" mission, launched in 2014, will target another Near-Earth asteroid, namely 162173 "Ryugu" (1999 JU3) which is a C-type asteroid. To learn more about the formation and evolution of our solar system, investigating different types of asteroids, namely S-, C-, and D-type, is mandatory. C-type asteroids such as "Ryugu" are interpreted as more primordial bodies than for example "Itokawa" and are considered to contain more carbonaceous, organic or hydrated mineral phases. Spectroscopical data show that this asteroid type might be closely related to primitive carbonaceous chondrites or comets in terms of material composition [3].

Very sophisticated techniques are required for the investigation of pristine "Ryugu" particles in our laboratories (return planed end of 2020). LASER Micro Raman Spectroscopy is perfectly suited for identifying and discriminating (extra-) terrestrial mineralogy: (a) fully non-destructive (repeated experiments possible on one and the same spot under variable conditions), (b) investigations with high sensitivity and in parallel high resolution, optionally in 3 dimensions, (c) as a major advantage experiments on pristine material without any preparation or coating, and (d) mineral polytypes (eg diamonds) can be well discriminated. Variable LASER frequencies allow to optimize and fine-tune the Raman system to specific sample and experiment requirements. High resolution scanning can produce very detailed distribution maps of selected mineral phases. Micron- or even nano-sized particles such as various diamond polytypes can be detected in this way. Within our Hayabusa sample analyses project we have successfully applied LASER Micro Raman Spectroscopy on several individual Itokawa particles [2].

Generally, the carbon-phase mineralogy has not really been investigated systematically in most meteorite types [4,5]. The main focus was on ureilites and certain carbonaceous chondrites [4-7], and priority was set on graphitic components and diamonds. The presence of very rare carbonaceous phases such as graphenes, fullerenes or nanotubes which can be exspected in a number of meteorite types has not been investigated to our best knowledge. Therefore we have started detailed and systematic investigations on the carbon-phase mineralogy of a larger set of various stony meteorite types. Priority is presently set on the following selected recent falls and finds [8-13]: (a) Ordinary chondrites Machtenstein H5 (find around 1956, classified 2014), Braunschweig L6 (fall 2013), Stubenberg LL6 (fall 2016), and for comparison the HED meteorite Saricicek (howardite fall 2015) as well as a large series of Almahata Sitta individuals [polymict ureilite, 12,13 and refs]. In our poster we will present first detailed results concerning the carbon phase mineralogy in these meteorites and will also focus on hypotheses concerning the possible formation processes of the meteoritic micro-nano diamonds [6,7,14,15]: (a) Chemical Vapor Deposition (CVD) and (b) shock metamorphism as optional in situ diamond producing processes, and (c) presolar diamonds of extrasolar origin (eg from supernovae explosions).

References

[1] http://global.jaxa.jp/projects/sat/hayabusa2/: last visit 9/2017.
[2] Mikouchi T. et al., 2014. Earth, Planets, Space, 66, pp82.
[3] Norton R.O., 2002. The Cambridge Encyclopedia of Meteorites. Cambridge Univ. Press.
[4] Ramdohr P., 1973. The opaque phases in stony meteorites. Elsevier, New York.
[5] Makjanic et al., 1993. Meteor. 28, 63-70.
[6] Szurgot M. et al., 2006. Nanodiam, PWN, Warszawa, pp259.
[7] Karczemska A.T., 2010. J. Achievm. Mater. Man. Engineer. 43/1, 94-107.
[8] https://www.lpi.usra.edu/meteor/metbull.php: last visit 9/2017.
[9] Hochleitner R. et al., 2015. LPSC #2453.
[10] Hochleitner R. et al., 2015. LPSC #1471.
[11] Bischoff A. et al., 2017. Meteor. Planet. Sci. 1-21, doi: 10.1111/maps.12883.
[12] Hoffmann et al., 2017. LPSC #2365.
[13] Hoffmann et al., 2017. Metsoc #6290.
[14] Gucsik et al., 2008. LPSC #1201.
[15] Hus G.R., 2005. Elements 1, pp97-100.