Meteorite chemistry and comparison with Rosetta comet data

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The chemical composition of chondrite meteorites will be characterized by time-of-flight secondary ion mass spectrometry (TOF-SIMS) and complementary spectroscopic techniques. The TOF-SIMS mass spectrometer is a twin laboratory instrument of the COmetary Secondary Ion Mass Analyzer (COSIMA) on board of ESA's Rosetta mission towards comet 67P/Churyumov-Gerasimenko. COSIMA will analyze cometary dust grains collected in the inner coma in the vicinity of the comet nucleus from November 2014 onwards. These cometary dust grains are expected to have chemical similarities with carbonaceous chondrites, an intimate mixture of minerals and organic compounds, but lacking the icy compounds contained in cometary grains. The results obtained from meteorites will support the evaluation of expected data from cometary matter.

Meteorite samples (carbonaceous and ordinary chondrites) will by provided by the Natural History Museum Vienna which has the largest, oldest and most diverse collection of meteorites worldwide. Typically, grains from meteorite samples with a diameter between 100 and 300 μm will be prepared on gold targets for analyses by COSIMA and the other methods.

Additionally to COSIMA (mass resolution, $m/\Delta m$, ca 1500; spatial resolution, d, ca 70 μm) the following methods will by applied for gaining complementary data about the chemical composition of sample surfaces: a high-performance TOF-SIMS instrument ($m/\Delta m$ ca 10,000, d ca 1 μm); a laser desorption ionization (LDI) mass spectrometer with MS/MS and imaging capability ($m/\Delta m$ ca 25,000; d 10 - 60 μm); an infrared imaging microscope (d 50 - 100 μm); and a Raman microscope (d ca 30 μm).

Characterization of the inorganic part of meteorite samples will focus on minerals as already detected in cometary grains by the missions GIOTTO and STARDUST and present in chondrite meteorites. Characterization of organic chemical compounds in meteorite and comet matter is highly relevant for prebiotic matter, however, is restricted by several facts: potential contamination of the samples; the recently found huge diversity (with more than 10,000 different molecular formulae $C_nH_mN_uO_v$ in extracts of the Murchison meteorite); and the limited mass resolution of the COSIMA instrument. In this sense the project will aim at characterizing classes of organic compounds and will relate the mineralogical with the organic composition.

An essential part of the project will be the development of chemometric methods (mostly multivariate statistical data analysis) for evaluation of the obtained multi-instrument, hyperspectral data with the aim to extract relevant chemical information automatically. Important tasks and new research topics are: multivariate classification of meteorite classes; development of multivariate methods for an improved determination of isotope ratios, and considering the compositional character of mass spectral data. Software will be developed within the programming environment "R", an open source activity.

The project results are expected to increase our knowledge about meteorites and asteroids, and to provide substantial support for the interpretation of Rosetta data (already available in the final part of the project); furthermore, fundamental contributions to surface analyses and the involved chemometrics are aimed.