Characterisation of meteoritic samples with the Rosetta Cosima TOF-SIMS laboratory reference model — a covariance approach

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The time-of-flight secondary ion mass spectrometer Cosima onboard Rosetta will analyze cometary grains ejected off the nucleus of comet 67P/Churyumov-Gerasimenko from September 2014 onwards. In our effort to understand the composition and the history of these cometary grains, we study the characteristics of different meteorite samples with the Cosima reference instruments at the Max Planck Institute for Solar System Research in Göttingen, with the goal to separate individual compounds and their fragmentation patterns.

Different types of meteorite samples are prepared in the laboratory. Among these are one ordinary chondrite H4 (Ochansk), one unequilibrated ordinary chondrite H3 (Tieschitz), one carbonaceous chondrite CR (Renazzo), and a martian shergottite (Tissint). Grains of sizes up to 100 μm are pressed into a blank gold metal target. The grains are identified with the instrument microscope and positive and negative secondary ion mass spectra are accumulated on different positions on selected grains. The mass spectra are accumulating all secondary ions up to mass 300 with reasonable detection efficiency and a mass resolution of 1400@ 100 amu. This mass resolution is sufficient to separate organic (hydrogen-rich) molecule peaks from minerals or elemental mass peaks.

We are trying to assess how the covariances of count rates between different parts of the mass spectra, i.e., specific atomic and molecule peaks of a single meteorite, can be used to infer some properties of its constituents and how this differs between the different meteorites that show varying degrees of alteration. In a first step, we look at the covariance and the correlation matrices S of the mass spectra for individual meteorite samples. The elements s_{ij} of S are the covariances/correlations of the mass spectra at the masses i and j for a given meteorite sample.

This will help us, after future analysis, to place the cometary grains into the proper compositional and evolutionary context within the solar system.