THERMAL STRESS-MARKER IN METEORITES: A MOLECULAR APPROACH WITH (ULTRA)HIGH RESOLUTION ORGANIC SPECTROSCOPY

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Introduction:

Understanding the origin and evolution of organic matter, is linked to observationally-derived astrochemistry (telescopic observations) and the laboratory wet chemical analysis of return objects and meteorites. The molecular composition and diversity of non-terrestrial organic matter in carbonaceous chondrites was studied by means of both, targeted [1] and non-targeted [2,3] chemical analytical approaches, leading to new insights. Targeted chemical analyses are hypothesis-drivenand are largely focused on molecules of biological/prebiotic interest. In a non-targeted approach, all analytes are globally profiled within the analytical possibilities without biased or constrained hypothesis in order to gain comprehensive information.

Ultrahigh-resolving analytics, like high field Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) and nuclear magnetic resonance spectroscopy (NMR), represent a powerful tool to allow insights into the holistic complex compositional space to tens of thousands of different molecular compositions and functional groups and likely millions of diverse structures. This could be observed in solvent extracts of pristine carbonaceous meteorits [2, 3], and suggests that interstellar chemistry is extremely active and rich. Since then we studied the chemical composition of thousands of individual components out of complex organic mixtures, as accessed in the solvent-accessible organic fraction, extracted under mild conditions, from diversely-classified and heated meteorites.

We described that heteroatomic organic molecules play an important role in the description of non-terrestrial chemical evolution. The thermally and shock-stressed Chelyabinsk (LL5) [4] showed high number of nitrogen counts within CHNO molecular formulas, especially in the melt region. This match of the organic molecular profile with the petrologic character could be also observed for Novato (L6) [5], Braunschweig (L6) and the latest German fall Stubenberg (LL6) [6]. Additionally, the extremely thermally altered Sutter's Mill (C-type) [7] reflects a loss in the organic diversity, but an increase in the polysulphur domain, as compared to other CM2-analyzed falls. The increase of polynitrogen and polysulphur compounds could be simulated in laboratory experiments by heating Murchison (CM2). Recently we reported the discovery of a previously unrecognized chemical class, dihydroxymagnesium carboxylates, $[(HO)_2MgO_2CR]^-$, gained from nonterrestrial meteoritic analyses [8]. The existence of such low-coordination organomagnesium anionic compounds expands our knowledge and understanding of extreme environments from which the early solar system emerged and has evolved. The appearance this CHOMg chemical class extends the previously investigated vast diversity of CHNOS groups in meteoritic soluble organics. Experimental evidence is given for the connection between the evolution of organic compounds and minerals. These thermostable compounds might have contributed to the stabilization of organic molecules on a geological time scale, which emphasizes their potential astrobiological relevance.

The resulted extreme richness in chemical diversity offers information on the meteoritic parent body history and help in expanding our knowledge or astrochemistry towards higher molecular masses and complex molecular structures.

References:

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