

## PROCESSING OF PRIMORDIAL ORGANIC COMPOUNDS IN CARBONACEOUS ASTEROIDS BY MILD AQUEOUS ALTERATION.

J. M. Trigo-Rodríguez<sup>1</sup>, Z. Martins<sup>2</sup> and A. Rimola<sup>3</sup>, <sup>1</sup>Institute of Space Sciences (CSIC-IEEC), Campus UAB, 08193 Bellaterra, Catalonia, Spain, trigo@ice.cat, <sup>2</sup>Department of Earth Science and Engineering, Imperial College London, London SW7 2AZ, UK, z.martins@imperial.ac.uk, <sup>3</sup>Departament de Química, Universitat Autònoma de Barcelona, 08193 Bellaterra, Catalonia, Spain, albert.rimola@uab.cat

**Introduction:** The carbon-rich matrix of carbonaceous chondrites (CCs) is a potential source of all biogenic elements, including phosphorus [1]. There is growing evidence pointing towards a prebiotic synthesis of complex organic species in water-rich undifferentiated bodies. For instance, many secondary minerals in CCs are aqueous alteration products. Among them, clays have been found to be associated with complex organic compounds [2–4], whereas theoretical calculations have studied the interaction between the organic species and surface minerals [5] as well as surface-induced reactions [6]. We are now using more detailed analytical techniques to study the possible processing of organic molecules associated with the mild aqueous alteration of CR, CM and CI chondrites. By using an attenuated total reflectance (ATR) spectrometer, we have recently concluded that the relationship between the abundance of organic molecules and clay minerals in CCs matrixes is a complex subject yielding broad qualitative discussions and depends on the particular parent body hydrous histories [7]. Accordingly, an interdisciplinary research is needed to significantly enrich our knowledge on this discipline. In this sense, our work has two goals: i) identifying the chemical steps in which the organic molecules could have increased their complexity (*i.e.*, surface interaction and catalysis); and ii) studying if the organic matter present in CCs experienced significant processing concomitant to the formation of clays and other minerals at the time in which these planetary bodies experienced aqueous alteration. These two points are preliminarily explored combining experimental results with theoretical calculations based on accurate quantum mechanical methods. Future experiments will focus on reproducing the catalytic action of water to form complex organic from basic precursors, using chondrite samples. Here we used calculations to simulate the interaction of different organic molecules representative of those found in meteorites with forsterite ( $\text{Mg}_2\text{SiO}_4$ ) silicate surfaces. The images on the right side of Figure 1 represent the interaction of glycine, pyrimidine and benzene with  $\text{Mg}_2\text{SiO}_4$ . The calculated binding energies (BE) evidence a clear trend between the organic functionalities of the molecules and the nature of their interaction with the silicate surfaces.

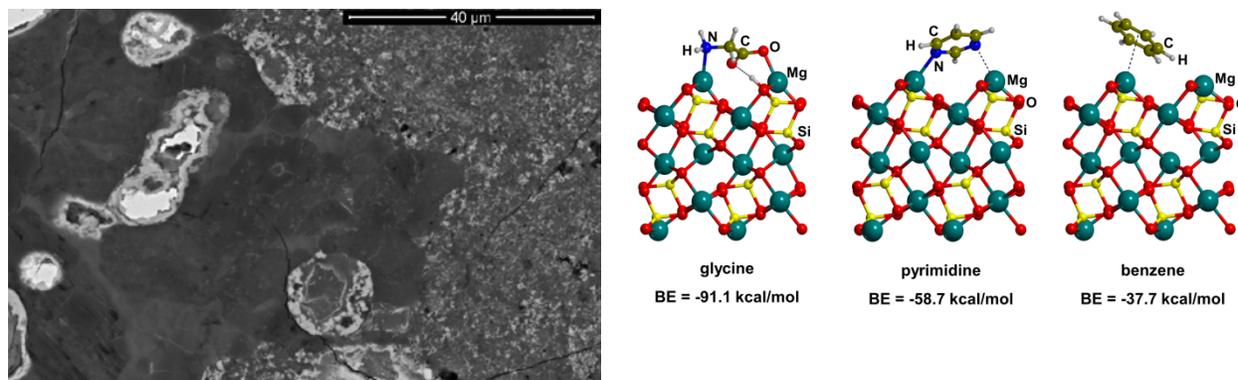


Figure 1. On the left a back-scattered electrons (BSE) image of a Mg-rich olivine chondrule of Renazzo, showing partial alteration of metal grains, and the interaction with a matrix with secondary minerals and organics. On the right, quantum chemical simulations of the interaction of glycine, pyrimidine and benzene with a forsterite ( $\text{Mg}_2\text{SiO}_4$ ) silicate surface, including the calculate binding energies (BE).

**References:** [1] Pasek M. and Lauretta D. 2008. *Origins of Life and Evolution of the Biospheres* 38:5–21. [2] Pearson V. K., Sephton M. A., Kearsley A. T., Bland A. P., Franchi I. A. and Gilmour A. 2002. *Meteoritics & Planetary Sciences* 37:1829–1833. [3] Garvie L. A. J. and Buseck P. R. 2007. *Meteoritics & Planetary Sciences* 42:2111–2117. [4] Arteaga O., Canillas A., Crusats J., El-Hachemi Z., Jellison G. E., Llorca J., Ribó J. M. 2010. *Origins of Life and Evolution of the Biospheres* 40:27–40. [5] Rimola A., Costa D., Sodupe M., Lambert J.-F. and Ugliengo P. 2013. *Chemical Reviews* 113:4216–4313. [6] Rimola A., Sodupe M. and Ugliengo P. 2007. *Journal of the American Chemical Society* 129:8333–8344. [7] Trigo-Rodríguez J. M., Moyano-Camero C. E., Llorca J., Formasier S., Barucci M. A., Belskaya I., Martins Z., Rivkin A. S., Dotto E., Madiedo J. M. and Alonso-Azcárate J. 2014. *Monthly Notices of the Royal Astronomical Society* 437:227–240.