DELALANDE Jacques-Léonard (2020) : The formation and evolution of proto clays in biofilms of a hypersaline evaporitic environment (Dohat Faishakh Sabkha): a Mars homologue

The evaporitic environments of the Arabian Gulf, known as “sabkhas”, were investigated as a terrestrial analogue to Mars, in order to document new proxies that could suggest past life on this planet. These environments may have promoted the growth of ancient microbial mats, whose exopolymeric substances could have biomineralized specifically recognizable clay minerals that would still be preserved on Mars. The objective of this study was to confirm the existence of such clays in the Dohat Faishakh sabkha, characterize them, and investigate their organic formation mechanisms in relation to EPS. The porosity of biofilm and the extracellular polymeric substances (EPS) and the use of novel Cryogenic Scanning Electron Microscopy (CryoSEM) methods allowed the production of detailed pictures of the mats. Combined with Energy Dispersive X-Ray Spectrometry (EDS), it revealed the morphology and elemental composition of likely authigenic rhomboedral dolomite, aragonite needles, and framboidal pyrite, as well as various heavy metals and fly ash artifacts. It revealed the spatial association of the EPS with an amorphous phase of protominerals nodules at various precipitation stages, which chemical composition could suggest the presence of intermixed clay phases within an organomineral matrix. X-Ray Diffraction (XRD) confirmed some of the minerals observed by CryoSEM, and revealed the presence of potentially authigenic clays such as smectite, kaolinite, palygorskite and chlorite in the fraction inferior to 2 µm that are consistent with the chemical composition revealed by EDS. Other detrital minerals in the larger fraction between 16 µm and 2 µm such as mica, quartz and feldspath have also been found with this method. Inductively coupled plasma – optical emission spectrometry (ICP/OES) was unable to detect Si, Al and Fe in seawater and brines due to their low concentration in hyper-saline conditions. However, it showed that some of the ions needed for the nucleation of these clays are present despite significant salinity variations in the microbial mat ecosystem. At the macroscopical scale, it also showed that there is no difference in salinity between the water and the inside of the mats. This suggests that osmosis dynamics prevails in the bulk of the porous EPS. It does not invalidate the existence of particular microdomains within the organomineral matrix with specific physicochemical conditions that could promote the precipitation of clays. The results in themselves cannot prove that the presence of these clays is linked to the authigenic influence of EPS, although they certainly suggest that it might be in deed possible. These results are promising for the identification of biomarkers on Mars, although better design could be implemented in order to eliminate methodological bias imposed by the open nature of these environments.