NA1 EPN2020 Exchange Programme Report

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Description and characterisation of microbial biosignatures from the early fossil record of South Africa

For the week of November 26th-November 30th, I visited the Dipartimento di Scienze Biologiche, Geologiche e Ambientali (BiGeA) of the Università di Bologna within the framework of the EPN Exchange Programme, where I worked in collaboration with Dr Barbara Cavalazzi (head of the Laboratory of Geomicrobiology and Astrobiology). During this week, we worked together of the description of exceptionally preserved microbial mats from the 3.45-3.47 Ga Hooggenoeg Formation (Onverwacht Group, Barberton greenstone belt, South Africa). These filamentous biofilms reflect some of the most ancient traces of life on Earth, and decoding their nature, and the nature of the palaeoenvironments, will provide significant advances in our understanding of habitability and the distribution of microbial biomes on the early Earth.

During the course of the week, Dr Cavalazzi and myself undertook a detailed reconnaissance of the microbial mat-rich samples in the collections at Bologna (example microstructural fabrics shown in Figure 1). We performed preliminary analyses of thin sections using SEM-EDS, and began the selection of samples for high-resolution *in situ* geochemical analyses. SEM-EDS gave us key constraints on the bulk composition of the samples, which we found to be consistent with a volcano-hydrothermal palaeodepositional environment. Some samples were selected and prepared for analysis by high-resolution transmission electron microscopy (HR-TEM), ion beam analysis, laser ablation ICP-MS and nano-scale secondary ion mass spectrometry. These analyses are currently underway and will continue until the summertime of 2019 (examples LA ICP-MS analyses presented in Figure 2). The ultimate goal of these experiments is a well-constrained framework of interpretation for the palaeoenvironment and metabolic networks represented in these ancient cherts in terms of aqueous chemistry and geological processes.

We were also able to study the distribution of microbial mats through other samples held in the collections at Bologna, including the Buck Reef Chert, a key example of well-preserved photosynthetic microbial mats dated at 3.42 Ga. Comparisons were made between the occurrence and morphologies of these microbial mats, which will assist us in defining morphogenetic interpretative schemes for microbial mats and stromatolites, an ongoing project in collaboration with researchers in Orléans.

During the week, it was also possible for me to attend a series of lectures on environmental geomicrobiology in extreme acidic environments given by Professor Ricardo Amils from the Universidad Autónoma de Madrid (Molecular Biology, Faculty of Science). These insightful lectures into modern extremophilic microbial biomes proved to be highly informative regarding our own samples. We were able to discuss with Prof Amils, in detail, the findings from these modern environments and how we might apply such understanding to our own samples and the reconstruction of Archaean palaeoenvironments.

The visit, enabled by the NA1 EPN2020 Exchange Programme, was a highly valuable opportunity to develop our ongoing collaboration in Archaean geobiology. Exchanging views regarding the sedimentological palaeoenvironments of these microbial biosignatures, together with the subsequent analyses by LA ICP-MS, has resulted in a manuscript currently under review by *Geochimica et Cosmochimica Acta*. Continuing analysis using HR-TEM and NanoSIMS will produce a second manuscript in the coming months.

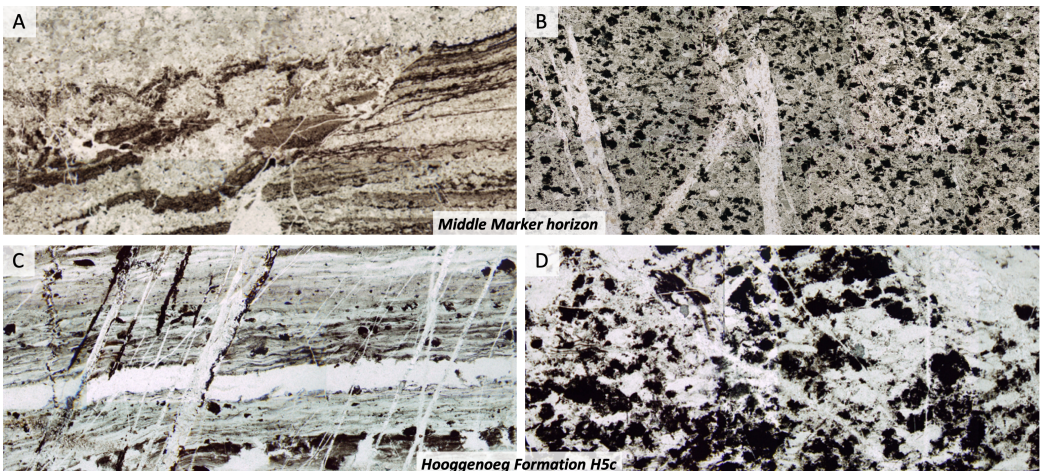

Figure 1. Example microbial mat fabrics from cherts of the Hooggenoeg formation (A, C) compared with massive chert lithologies (B, D).

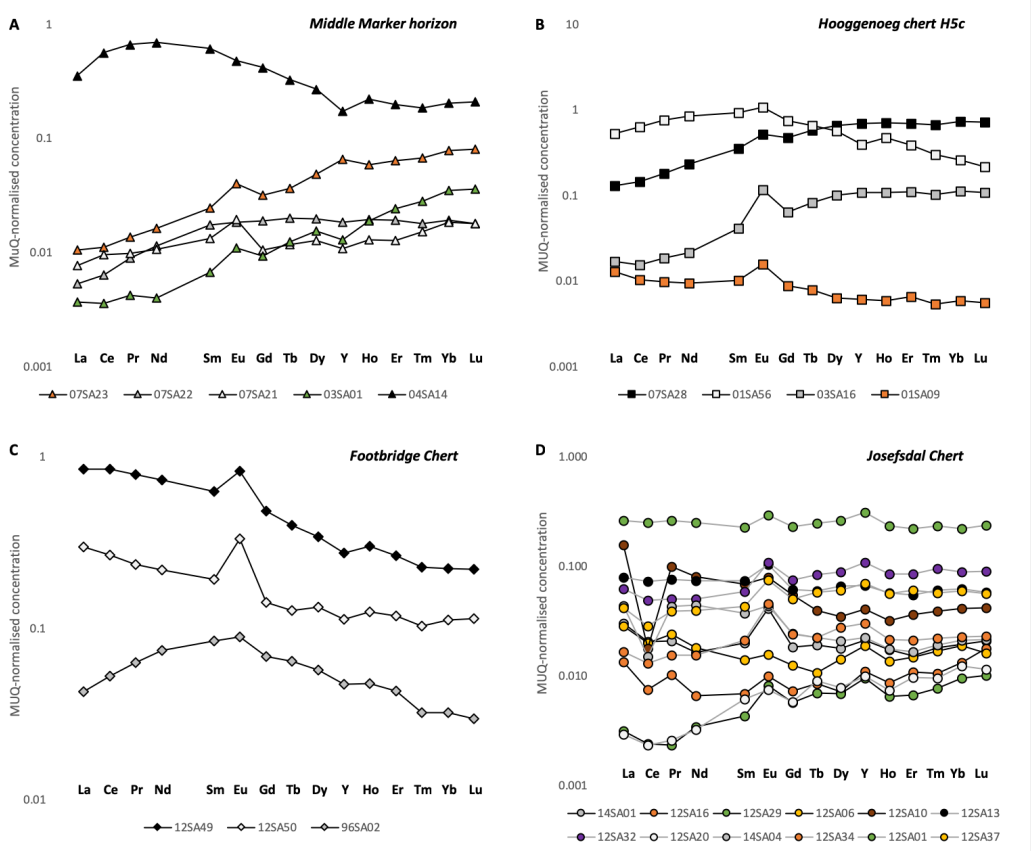

Figure 2. Laser ablation ICP-MS analyses including some of the samples selected for analysis during the Exchange visit (A-B) compared with previously analysed samples from the collections in Orléans. The normalised rare earth element plus yttrium patterns show the influences of marine hydrogenous, terrigenous and hydrothermal fluid inputs.