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Linking microbial assemblages to paleoenvironmental conditions from the Holocene and Last Glacial Maximum times in Laguna Potrok Aike sediments, Argentina

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Laguna Potrok Aike is a closed basin located in the southern hemisphere's mid-latitudes (52°S) where paleoenvironmental conditions were recorded as temporal sedimentary sequences resulting from variations in the regional hydrological regime and geology of the catchment. The interpretation of the limnogeological multiproxy record developed during the ICDP-PASADO project allowed the identification of contrasting time windows associated with the fluctuations of Southern Westerly Winds. In the framework of this project, a 100-m-long core was also dedicated to a detailed geomicrobiological study which aimed at a thorough investigation of the lacustrine subsurface biosphere.

Indeed, aquatic sediments do not only record past climatic conditions, but also provide a wide range of ecological niches for microbes. In this context, the influence of environmental features upon microbial development and survival remained still unexplored for the deep lacustrine realm. Therefore, we investigated living microbes throughout the sedimentary sequence using in situ ATP assays and DAPI cell count. These results, compiled with pore water analysis, SEM microscopy of authigenic concretions and methane and fatty acid biogeochemistry, provided evidence for a sustained microbial activity in deep sediments and pinpointed the substantial role of microbial processes in modifying initial organic and mineral fractions.

Finally, because the genetic material associated with microorganisms can be preserved in sediments over millennia, we extracted environmental DNA from Laguna Potrok Aike sediments and established 16S rRNA bacterial and archaeal clone libraries to better define the use of DNA-based techniques in reconstructing past environments. We focused on two sedimentary horizons both displaying in situ microbial activity, respectively corresponding to the Holocene and Last Glacial Maximum periods. Sequences recovered from the productive Holocene record revealed a microbial community adapted to subsaline conditions producing methane with a high potential of organic matter degradation. In contrast, sediments rich in volcanic detritus from the Last Glacial Maximum showed a substantial presence of lithotrophic microorganisms and sulphate-reducing bacteria mediating authigenic minerals.

Together, these features suggested that microbial communities developed in response to climatic control of lake and catchment productivity at the time of sediment deposition. Prevailing climatic conditions exerted a hierarchical control on the microbial composition of lake sediments by regulating the influx of organic and inorganic material to the lake basin, which in turn determined water column chemistry, production and sedimentation of particulate material, resulting in the different niches sheltering these microbial assemblages. Moreover, it demonstrated that environmental DNA can constitute sedimentary archives of phylogenetic diversity and diagenetic processes over tens of millennia.