# Recognizing microbial life preserved in rocks: insights from population morphometry

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The identification of microfossils in the Archean rock record is fraught with difficulty, since early life forms were simple cells that lacked sufficient morphologic complexity to be efficiently distinguished from abiologic features in rocks such as pore-fillings, botryoidal crystals, exfoliated crystals, and fluid inclusions. Such objects can contain or be coated by (a)biologic hydrocarbons, resulting in microstructures that mimic the remains of microbial cells. These uncertainties have led to many re-interpretations of individual microstructures in the ancient rock record. One critical aspect of unicellular life, however, is the occurrence of many identical, spatially associated specimens that reflect a microbial population. The question is whether such preserved biologic populations can be distinguished from populations of the objects mentioned above. Here we present a statistical approach on the quantitative morphological description of biologic and abiologic microstructure populations and the morpho-space they occupy. In order to do this, several pictures of modern microbial populations were compared to two relevant types of abiologic microstructures already discussed in the context of Archean micropaleontology: interstitial space fillings and complex biomimetic mineral aggregates (silica-witherite biomorphs). The spatial organization, size and shapes of microstructures in the pictures were characterized and used to identify differences between populations of these biologic and abiologic entities. For bacteria, the polymodal size distribution was linked to the composite nature of a community; the independence of shape and size was linked to the biological internal control of shape; and the clustering was linked to division and migration processes. Discriminant analyses were run in order to assess the potential of different sets of parameters to discriminate the three systems in 2-D morphospaces. Notably, parameters describing statistical distributions allowed a good discrimination between populations from these three systems. These results indicate the great potential of morphometric descriptions of populations in the context of life recognition in rocks, either on Earth or on extraterrestrial bodies.