Biogenic or not? Morphometric analysis of filamentous structures

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Abstract

Filamentous shapes are common among extant microbial life forms and have also been reported for microbial fossils in ancient sedimentary rocks. In addition to sediments, various types of rocks, including volcanics, oxidized ore deposits and karst environments in sediments do host mineralized filamentous forms in ancient cavities and fissures, representing former subsurface environments. The presence of filamentous textures in a large variety of environments, both sedimentary and subsurface, warrants the ability to distinguish biogenic from non-biogenic origins of filamentous forms. We have further developed a morphometric approach by measuring shape parameters in order to discriminate filaments of different origins. We have focused on microscopic parameters but also extended the approach to images of macroscopically visible filament-induces textures. Diameters and shapes of filamentous forms are determined on images using ImageJ, shape parameters such as bending, direction changes and orientation are then calculated using a spreadsheet. Groups of investigated materials are a) bona fide microbial filaments, b) mineral fibres (fibrous/whisker crystals, volcanic glass) and c) filamentous forms from "chemical garden" experiments. Morphometric parameters determined using microscopic images are 1) innermost diameter of filaments; 2) variability of innermost diameter; 3) degree of bending of filaments; 4) number of direction changes per unit distance. A "filter" based on the biogenic filaments shows only a 12% overall match with the suite of non-biogenic samples (100% with biogenic samples). Measurements on new samples with filaments from diverse geological environments (Piz Alv and Bitsch, Switzerland, Indian moss agate, oxidized meteorite) show a high probability for a biogenic origin in all cases (overall match 81%). A morphometric approach currently appears as the only possibility to distinguish biogenic filaments from similar forms of non-biogenic origin in geological samples. We continue to extend the database both using the microscopic and macroscopic approach, with a special focus on filamentous forms from the Indian Deccan traps, where the sequence and age of secondary minerals has been studied in detail. During upcoming missions on Mars, morphometry may be a tool for characterizing potential biogenic structures observed by imaging instruments, e.g. CLUPI on the ExoMars rover.

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