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Advantages of Doubly Polished Thin Sections in the Study of Fossilized Microorganisms in Volcanic Rock

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A deep subsurface biosphere is thriving in the upper volcanic part of the oceanic crust. The constantly growing knowledge about this environment calls for new perspectives within geomicrobiology and new methods to meet such needs. Compared to bacteria found in oceanic sediments these microorganisms are found in cracks and veins within basaltic rocks. These rocks are usually hydrothermally altered and the veins are filled with secondary minerals like carbonates or zeolites in which the fossilized microorganisms are preserved.

When studying fossilized microorganisms in hard rock, optical microscopy of thin sections is an inevitable tool and probably the only technique to study the isolated interior of the rock samples without contaminating it. Doubly polished thin sections contain properties which make them even more suitable for the study of microfossils compared to ordinary thin sections. They are polished on both sides without mounting them on a glass slide, and they are thicker ($\sim$200 μm), compared to ordinary thin sections, ($\sim$30 μm). This is of significance since bacterial filaments sometimes are over 30 μm in length. These properties result in higher visibility, better light conditions and an increased three-dimensional view. The possibility to view the sample from both sides is of great advantage in the study of morphology, internal microstructures, colonies and interactions between the microfossil and the associated substrate. However, the greatest advantage by using doubly polished thin sections is, since they are originally prepared for fluid inclusion studies, the possibility to combine both fluid inclusion studies and microfossil studies. Fluid inclusions provide information about the compositions, salinities and temperatures of the hydrothermal fluids that circulated through the rock when the microfossils once lived. This makes it possible to place the

fossilized microorganisms in a geological and environmental context as well as to study the environmental limits for microbial life.

Samples from ODP Leg 197, drilled on the Emperor Seamounts in the Pacific Ocean, have been used to apply and develop this method. Fossilized iron-oxidizing bacteria were found attached to volcanic glass and embedded in calcite, aragonite and gypsum. The microfossils were divided into four different classes according to morphology: sheaths, segmented filaments, amorphous filaments and twisted filaments. Fluid inclusion studies show that the microorganisms could exist at temperatures up to 150˚C during shorter periods of hotter fluid regimes. Changes in neither salinity nor in fluid compositions appear to have any affect on the occurrence of the microorganisms. The fluids were dominated by H_2O-NaCl-$MgCl_2$ and H_2O-NaCl-KCl compositions with salinities ranging between 2.1 and 10.5 eq. wt. % NaCl. However, fluid flow seems to influence the occurrence of microorganisms. They seem to prefer small, narrow veins where the fluid flow is restricted.

One of the most important criteria for microfossil recognition is that the geological context must be known, and be compatible with the environment of living organisms. By using doubly polished thin sections and the combination of fluid inclusions and microfossil studies it is possible to place the microorganisms in an environmental context with high accuracy and precision.