Division by fluid incision: Biofilm patch development in porous media

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Bacterial biofilms often occur in porous media, where they play pivotal roles in medicine, industry and the environment. Though flow is ubiquitous in porous media, its effects on biofilm growth have been largely ignored. Using patterned microfluidic devices that simulate soil, we find that the structure of *Escherichia coli* biofilms undergoes a self-organization mediated by the interaction of growth and flow. Intriguingly, we find that intermediate flow rates trigger the formation of striking preferential flow channels, which convey fluid around large biofilm patches (Fig. 1). At larger and smaller flow rates, biofilms form more compact patches leading to uniform flow through the matrix. A simple network model, based on the competition between biofilm growth and shear induced detachment, correctly predicts our findings. These findings may have important consequences on processes as diverse as biochemical cycling, antibiotic resistance, and water filtration.

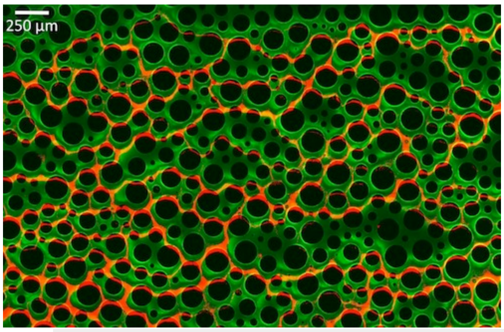

Figure 1: A microfluidic device that simulates soil colonized by *E. coli* biofilm (bacterial auto-fluorescence shown in green). Biofilm patches are intersected by channels of fluid flow (shown in red and shifted slightly downward to reveal the underlying structure), which transport nutrient unevenly through the matrix.

Assessment of the evolution of the redox conditions in a low and intermediate level nuclear waste repository (SFR1, Sweden)

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This study evaluates the redox conditions in 15 individual waste package types in SFR1. SFR1 contains heterogeneous wastes, with different activity levels and materials in the waste, matrices and packaging. Steel and concrete-based materials are ubiquitous in the repository. A combination of the individual models is used to assess the redox evolution of the different vaults in the repository. The results of the model indicate that O_2 is consumed through organic matter degradation and metal corrosion. The system is then kept under reducing conditions for long time periods. H_2(g) is generated due to the steel anoxic corrosion and magnetite precipitates as main corrosion product. Steel is depleted after 5,000 y to more than 60,000 y depending on the waste package type. The calculated Eh under the pH conditions imposed by the massive amounts of cements in the repository is about -0.75 V (pH 12.5) but higher redox potentials (up to -0.01 V) can be expected if the system controlling the Eh is not steel/magnetite, but Fe(III)/magnetite. If no oxic disturbances happen Eh would be kept highly reducing. In case of glacial meltwater intrusion magnetite would gradually convert into Fe(III) oxides, buffering system Eh and preventing it from oxidation for long time periods.

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