The impact of gas on flow of DNAPL in porous media

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In order to investigate the multiphase flow and migrate of dense non-aqueous phase liquid (DNAPL) in a gas/water two phase system in porous media, two DNAPL infiltration experiments were conducted in a two-dimensional sand-filled cell (55 cm wide x 45 cm high x 1.28 cm thick). TCE was selected as DNAPL. In the first experiment, TCE was injected to the cell under water saturated condition. About 213ml of TCE was injected. In the second experiment, after 223 ml of air displacing water, TCE was added to the cell under gas/water two phase condition. About 194 ml of TCE was added. Light Transmission Method was applied to monitor the DNAPL flow process [1] and quantify DNAPL saturation. Comparing the results of the two experiments, the gas phase hindered the horizontal movement of TCE, shown as Fig.1 and Fig2. The volume of TCE calculated by its saturation obtained from the light transmission method agreed with that recorded injection volume under water saturated condition and gas/water two phase condition, and the migration process of TCE was clearly demonstrated by dynamic variations of the light intensity.

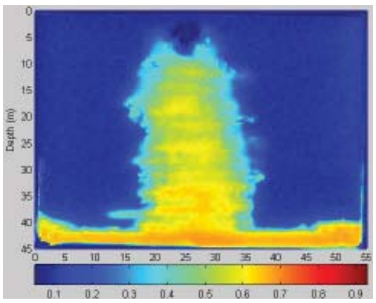

Figure 1: The distribution of TCE saturation in the flow cell in NAPL/water two phase system

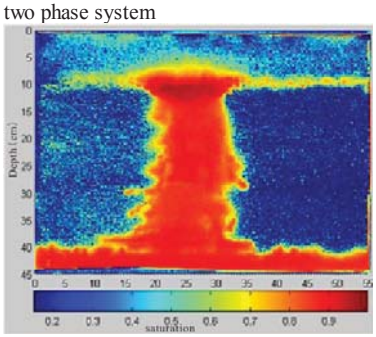

Figure 2: The distribution of TCE saturation in the flow cell in NAPL/water/gas three phase system

Acknowledgements

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[1] Niemet & Selker (2001) Adv. Water Res. **24**, 651-666.

Genome-enabled study of alternate respiratory pathways in a novel As(V)-respiring bacterium

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Background

A redox hierarchy based on thermodynamics is frequently invoked to explain the microbial utilization of electron acceptors in which the substrate that provides the most energy for cell growth is preferentially reduced. However, recent experimental and modeling studies have suggested that a thermodynamic ladder of electron accepting processes does not always develop in anaerobic microbial systems. From a physiological perspective, microbes may have evolved growth and respiratory mechanisms that do not follow the electron tower paradigm.

Desulfurispirillum indicum strain S5 is an obligate anaerobic bacterium belonging to the phylum *Chrysiogenetes*. This organism is able to grow by respiring arsenate to arsenite, nitrate to ammonium, as well as selenate and selenite to elemental selenium. From genome analysis, the genes encoding for respiratory arsenate reductase (Arr), periplasmic nitrate reductase (Nap) and the membrane-bound nitrate reductase (Nar) have been identified. Using this genomic information, we carried out gene expression and growth experiments to test the redox hierarchy hypothesis in strain S5.

Materials and Methods

Strain S5was grown anaerobically in a mineral salts medium containing nitrate and/or arsenate as the electron acceptor. Growth was monitored by measuring the optical density and direct cell counts. The loss of arsenate and nitrate from the culture medium was monitored using ion chromatography. Gene expression of *D. indicum* growing under arsenate and nitrate reducing conditions was examined using qRT-PCR. Primer pairs were used for the specific detection of *arrA*, *narG*, and *napA* genes. After RNA extraction and DNAse treatment, qRT-PCR reactions were carried out using the iScript One-Step qRT-PCR with SYBR Green Kit.

Results and Discussion

Consistent with thermodynamic predictions, the experimental results showed that the reduction of nitrate to ammonium yielded higher cell densities than the reduction arsenate to arsenite. However, S5 grew considerably faster by respiration on arsenate compared to nitrate, with doubling times of 4.3 ± 0.2 h and 19.2 ± 2.0 h respectively. S5 growing on both electron acceptors exhibited the preferential utilization of arsenate before nitrate. The expression of the arsenate reductase gene *arrA* was up-regulated approximately 100-fold during arsenate reduction, as determined by qRT-PCR. Conversely, the nitrate reductase genes *narG* and *napA* were constitutively expressed under the conditions tested. The results of this study suggest that physiology, rather than thermodynamics, controls the growth rates and hierarchy of electron acceptor utilization in *D. indicum* strain S5.