# Linking microbial activity to cell identity in the environment using NanoSIMS

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Linking identity of microorganisms to their activity in the environment remains a major gap in our ability to explore the microbial world. Recently this situation had changed by the development of nanometer-scale secondary ion mass spectrometry (nanoSIMS). Here we present a novel method, Halogen *In Situ* Hybridization-Secondary Ion Mass Spectroscopy (HISH-SIMS), and show that it allows simultaneous phylogenetic identification and quantitation of metabolic activities of single microbial cells in the environment. The method uses horseradish-peroxidase-labeled oligonucleotide probes and fluorine-containing tyramides for the identification of microorganisms in combination with stable-isotope-labeling experiments for analyzing the metabolic function of single microbial cells. Using HISH-SIMS, individual cells of the anaerobic, phototropic bacteria *Chromatium okenii*, *Lamprocystis purpurea* and *Chlorobium clathratiforme* inhabiting the oligotrophic, meromictic Lake Cadagno, have been analyzed with respect to $H^{13}CO_3^-$ and $^{15}NH_4^+$ assimilation. Metabolic rates were found to vary greatly between individual cells of the same species, showing that microbial populations are comprised of physiologically distinct individuals. Furthermore, the least abundant species had the highest contribution to the total uptake of ammonium and carbon, thereby emphasizing that numerically inconspicuous microbes can play a significant role in nutrient cycles in the environment. Our study opens new possibilities of research in environmental microbiology, by increasing the ability to examine the ecophysiological roles of individual cells, and by the capacity to track not only nitrogen and carbon but also other biological element flows within microbial communities.

# Concentration of the trace-elements in heavy oil and bitumen of Tatarstan

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Our study area is confined to the central portion of the Volga-Ural Anteclise (VUA) in the eastern part of the East European Platform. VUA is the largest structure of the Russian Plate. It is one of the structures typically occurring on the margins of continental platforms affected by pericratonic downwarping. This is characterised by the stepwise, monoclinal plunging of the basement surface toward the folded Urals. The tectonic structure and history of geological development of this region are mainly defined by the fact that Tatarstan is a junction between several first-order tectonic elements, – primarily, the South and North Tatarstan arches, Melekes trough, Kazan-Kazhim platform trough, and Tokmovo arch. The geological structure of the South Tatarstan Arch and the adjacent areas is composed by the Archaean, Proterozoic, Palaeozoic, Mesozoic, and Cenozoic formations. The major portion of the area under study is characterised by the two-storey structure of the geological sequence represented by the Archaean/Proterozoic crystalline basement, which is covered by the Phanerozoic sedimentary sequences (from the Middle Devonian) with a total thickness of 1500 m to 2000 m. The South Tatarstan arch contains Tatarstani largest oil fields – Romashkino, Novo-Elkhovo and Bavli. The area of maximum accumulation of the Permian bitumen in Tatarstan coincide with the Melekess trough and an adjacent part of the South Tatarstan Arch. Most of the revealed deposits are connected with three bitumen-bearing complexes: the Ufimian, the Lower Kazanian and the Upper Kazanian. In the Lower Permian carbonate complex, which was poorly studied, one commercial deposit was discovered and the presence of bitumen was stated. The microelement petroleum study, conducted in Tatarstan permits the recognition of three oil types: (1) of the Melekes trough, (2) of the central part of the South Tatarstan Arch and (3) of the Bavli oil fields, varying in amount of Mo, Se, Au, Ag and Hg. Some portions of the Minnibaevo oil area contain higher concentrations of Ba, Hf and W, and the Zelenogorsk oil area has the high tantalum content. Asphaltenes have been found to contain elements, greatly varying in their geochemical properties, which could have only been transferred by the abyssal reducing fluids that had made them neutral to matrix. At the same time, naphthoids can be differentiated on the basis of genetically sensitive lanthanoids (Gottikh *et al.,* 2000). The studies conducted by Prof. Rimma Gottikh and Prof. Bogdan Pisotsky indicate that the permeable basement zones in Tatarstan are associated with geochemical anomalies produced by rare-earth and other metals in the sedimentary rocks of the Domanik, Okskian and Upper Permian sequences. Periodicity of the formation of geochemical anomalies in the sedimentary cover indicates that the potentially permeable basement zones became fluid conductive during the periods of tectonic activity. The distribution of trace-element in heavy oil and bitumen from Permian and Carboniferous deposits was studied.