ÖZEL OTURUM - *SPECIAL SESSION*

Microbes, Tectonics and Life: ~4 Billion Years of Experimentation in Earth's Evolution

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Plate tectonics has been a fundamental process in the geological evolution of the planet Earth, primarily for production and destruction of lithospheric plates, dissipating heat and energy, and fertilizing the lower mantle through sediment recycling. It also drives the cycling of volatiles that in turn regulates the composition of the atmosphere and thereby the Earth's surface temperatures. Creation of land surfaces, redistribution of oceans, enhancement of biodiversity, and regulation of atmospheric compositions by tectonic processes through time have controlled planet habitability and life on Earth. During the first half of Earth's 4.6 billion year history, microbes played a major role in controlling a set of metabolic processes, which altered the chemical speciation of all elements on its surface. Microbially catalyzed, thermodynamically constrained chemical reactions control the biological fluxes of the elements H, C, N, O and S, whereas tectonically driven volcanism and rock weathering resupply C, S and P on geological time-scales. Thus, the current life and bioenvironment on Earth is an artifact of prolonged microbial experimentation on a water-covered planet driven by a plate tectonic engine. Recent findings of ~4 Ga granitic crustal rocks with metasomatized mantle signatures, high-pressure subduction zone metamorphic rocks, and suprasubduction zone ophiolites in various Archaean terranes suggest that Phanerozoic-type plate tectonics was already operating about 500 m.y. after the formation of the Earth. From the earliest anoxic atmospheric and oceanic conditions and the late heavy bombardment (LHB) in Hadean–Eoarchaean times to the increased O_2 and dramatically reduced CH_4/CO_2 ratios in the Neoarchaean and throughout the Proterozoic and Phanerozoic, microbes survived as the core biological machines driving biogeochemical cycles. Near-surface and subsurface microbial biospheres persisted through the Snowball Earth conditions, catastrophic meteorite impacts and massive volcanic outgassing events that resulted in mass extinctions of plants and animals in Earth's history.

The significance of microbes and microbial activities in the geological evolution of the Earth has been a subject of intensive, integrated studies only during the last 15 years. Microbes are now widely known as important geological agents in mineral growth and dissolution, mobilization of metals in metal sulfides, metabolism of hydrocarbons and transformation of organic carbon in sediments for fossil fuel formation, fractionation of stable isotopes facilitating mineral and rock diagenesis, porosity generation in deep-subsurface, and bio-remediation. How we can recognize ancient microbial activities in the rock record and in deep time (Archaean), how we can detect microbial systems in extreme environments, and how we can use all this information to investigate the possibilities of extraterrestrial life are currently some of the most fundamental and challenging questions in the broad field of sciences. This paper will present the highlights of recent research on the complex interactions of microbes, tectonics and life in Earth history and will provide a scientific backdrop for the other talks in this symposium.