# The Connection Between Life and Oceanic Volcanism: Biosphere Meets Lithosphere

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Life and volcanoes have been intimately connected since the beginning of life on Planet Earth. Microbial trace fossils in volcanic glass are amongst the earliest well preserved physical fossils on earth and we can trace the association of microbes with volcanic features throughout the geological record. Interactions between volcanoes and life may occur in diverse settings, in the deep biosphere and hydrothermal systems, in the hydrosphere and at the earth's surface and atmosphere. The total biomass associated directly or indirectly with oceanic volcanoes may comprise a substantial fraction of the total biomass on Earth. Volcanoes are known to impact life, as volcanic aerosols disrupt air traffic, change the earth's radiation budget and cause tsunamis (e.g. Thera and Krakatoa). Consequenes for civilization may be substantial, with well documented changes in climate, crop failures and major loss of life and property, including the destruction of an entire culture. Oceanic volcanoes are particularly relevant as the most common and voluminous volcano type and for their immediate interaction with the oceanic/atmospheric systems that control many key global geochemical cycles.

Feedbacks between life and volcanoes are best studied using combined geo- <u>and</u> biological investigations. There is a clear relationship between microbial activity and many types of mineralization. Distinct microbial communitites are known to preferentially colonize particular substrates. Their activity may accelerate substrate dissolution processes and distinct microbial dissolution fabrics. There are remarkable similarities in sub-sea basalt-hosted microbial communities with the ones in terrestrial soils, in terms of diversity as well as the relevance of *eukarya*, *prokarya* and *archea* . We are beginning to understand specific microbial consortia associated with volcanic rock and their main functions such as their capabilities to gain energy from chemolithotrophic reactions and their mechanisms for carbon fixation. We are beginning to explore many details of the genetic underpinnings of microbial function specializing in volcano/ hydrothermal interactions. However, there remains much room for illuminating the geological/ geochemical controls of extremely slow-growing microbial communities, microbial evolution in the geological record and the biological controls of global geochemical cycles, amongst many other issues.

# Inert nano-reactors or dynamic micelle intrefaces? $CaCO_3$ precipitation from microemulsions

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Reverse microemulsions are, thermodynamically stable suspensions of water droplets in oil i.e. micelles that are stabilised by an interface surfactant. Water droplets are typically 1-50 nm in diameters and can carry dissolved salt ions and exchange their content upon collisions, which lead to mineral precipitation. These droplets are believed to act as "nano-reactors" because precipitation occurs in the water pools shielded by the surfactants from the oil phase

Here we show how we can use microemulsions to elucidate the formation of $CaCO_3$ phases and stabilise initial amorphous stages. Micelles are used to confine volume in which nucleation and growth occurs. Mixing of two distinct microemulsions containing $Ca^{2+}$ and $CO_3^{2-}$ ions leads to a reproducible method to make nano-sized, monodisperse particles. However, there is no correlation between the initial droplet size and the size of solid $CaCO_3$ particles, which are considerably larger than the original micelles. Therefore, the notion of a "nano-reactor" may in this case be inaccurate, because it implies the formation of an inert, impenetrable water-surfactant-oil interface that limits the growth to a single droplet.

By using time-resolved and *in situ* small and wide-angle X-ray scattering and high-resolution imaging we demonstrated that $CaCO_3$ grows through a continuous but progressive and slow disintegration of the micelles, rather than precipitation inside of individual droplets. Upon destabilisation of the original salt-ion carrying micelles, new water-mineral-surfactant interfaces are created. These constitute a nucleus and they direct further growth. The formation of this interface is crucial in stabilising amorphous $CaCO_3$ in the form of nanoparticles (30-100 nm) and this also slows down or prevents further growth and crystallization.

We believe that these findings are relevant for understanding of the $CaCO_3$ growth mechanisms occurring at water-nonpolar liquid interfaces in natural and industrial environments (e.g. preventing scale formation). Microemulsions could also be a good analogue model system for mineralization of coccolith plates formed within the cell vesicles produced in the Golgi apparatuses of coccolithophores.

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