Oxygenic photosynthesis from 2.9 to 2.6 Ga: Prologue to a better life

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The evolution of life in the Archaean progressed from simple metabolism to more complex and abundant biological activities, directly related to the gradual improvement of the environment for the bacterial pioneers. At the dawn of the late Archaean, the presence of important stromatolitic formations suggests a dramatic global change in these activities.

Stable isotopic studies on ~2.9Ga stromatolitic sequences, from Steep Rock Group, Ontario and Mushandike Formation, Zimbabwe, give $\delta^{13}C$ values around 0‰ for carbonates, and between -31 and -22‰ for $\delta^{13}C$ of organic matter. The simplest explanation of this fractionation is that it records of C selection by the Rubisco 1 enzyme in oxygenic photosynthesis, suggesting that cyanobacterial communities were flourishing long before the rise of atmospheric oxygen ~2.3Ga ago. If so, oxygen release would have been occurring into the Archaean atmosphere/ocean system 2.9 Ga ago.

Prior to ~3.0 Ga ago, the atmosphere was probably CO_2-and CH_4-rich, and anoxic. The evolution of cyanobacterial oxygenesis in the photic zones of Archaean oceans would have irreversibly transformed microbial productivity. From then, the available oxygen, despite remaining in small quantity, had a strong impact on the bacterial communities. The Belingwe Greenstone Belt, Zimbabwe, (2.7-2.6 Ga old), is a remarkable example of how the variety of biological activities expanded. Well-preserved black shale and chert sequences reveal diverse and complex microbial consortia, with much wider isotopic ranges than found in earlier Archaean sequences. The scope of S-dependent metabolism was particularly expanded, with a $\delta^{34}S$ range of 40‰. The 36‰ $\delta^{13}C$ range in organic matter is also large. Stromatolitic structures contemporaneous with the two Belingwe successions studied (Manjeri Fm. and Cheshire Fm.) have $\delta^{13}C$ values indicating isotopic fractionation by Rubisco I. Collectively, these results suggest that C and S biological cycles were already very complex in the Late Archaean, with co-existing microbial activities such as sulphate reduction, sulphide oxidation, methanogenesis and methanotrophy, with dominant and beneficial oxygenic photosynthesis.

The global atmosphere ~2.7 Ga ago was probably anoxic, over oxygen-rich photic-zone water. During periods when the oxygen productivity was limited, anoxia would return. Life would have had to accommodate this insecurity, recorded in sediment by more extreme $\delta^{34}S$ and $\delta^{13}C$ signatures.

Biogenic methane production from subsurface petroleum systems: organisms and mechanisms

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Subsurface anaerobic alteration of hydrocarbons has led to the World's vast but economically less valuable heavy oil deposits. However, anaerobic hydrocarbon degradation has probably also played a signiicant role in the formation of economically valuable gas accumulations. In laboratory based methanogenic microcosms oil degradation mimicked the preferential removal of n-alkanes commonly observed in petroleum. The bacterial community in methanogenic oil-degrading microcosms was enriched with species closely related to those identified in petroleum reservoirs and a number of methanogenic hydrocarbon degrading systems. In particular members of the genus *Syntrophus* (*Deltaproteobacteria*) and *Anaerolineae* (*Chloroflexi*) were predominant. The congruence of species found in different methanogenic hydrocarbon associated environments suggests common mechanisms of methanogenic oil degradation. Selection for hydrogenotrophic rather than acetoclastic methanogens in oil degrading microcosms suggested that methanogenic alkane degradation was dominated by CO_2 reduction linked to hydrogenotrophic methanogenesis and syntrophic acetate oxidation. Although the isotopic composition of methane and CO_2 from some biodegraded petroleum reservoirs supports the dominance of CO_2 reduction in those settings, other studies have shown the dominance of acetoclastic methanogenesis in methanogenic hydrocarbon-degrading systems. While the ecophysiology of methanogenic oil degradation is not yet fully understood it has been proposed that *in situ* methanogenic biodegradation of oil could be harnessed to enhance recovery of stranded energy assets from petroleum reservoirs. Methanogenic enrichment cultures from production waters of an oil rimmed gas accumulation belived to have formed by microbial conversion of oil to methane has established the presence of putatively indigenous fermentative bacteria and methanogens and stimulation of their activity by inorganic nutrients.