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Archaean microbial evolution: The age of Rubisco

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Archaean microbial evolution can be mapped out by its isotopic consequences. Rubisco (ribulose bisphosphate carboxylase/oxygenase) governs most biological extraction of carbon from air and hence rubisco controls are important in determining the isotopic partitioning of carbon and the atmospheric ratio of carbon dioxide to oxygen.

The early record is poor. Isotopic signatures in reduced carbon in rocks from Barberton South Africa (3.5 Ga) and Isua, Greenland, (3.8 Ga) imply the presence of organisms using Rubisco II and Rubisco-like protein (RLP). These organisms probably included sulphur-processing bacteria and methanogenic archaea.

By mid-late Archaean the record is better. Carbon and sulphur isotopes from rocks in Steep Rock Ontario imply that fractionation by Rubisco I is at least 3.0 Ga old. This strongly suggests that cyanobacteria were present. By 2.7 Ga ago, the extremely well-preserved rocks of the Manjeri and Cheshire Formations, Belingwe belt, Zimbabwe, show that a complex and sophisticated microbial biosphere existed.

Major later branches in Rubisco phylogeny may record Proterozoic snowball events. After the snowball 2. 3 Ga ago Rubisco compensation controls may have maintained the strong atmospheric disproportion between O_2 and CO_2.