Atmospheric oxygen between 3.5 and 1.5 Ga

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The isotopic composition of nitrogen in the remains of microfossils (Beaumont and Robert, in press) suggests that photosynthesis 3.4–3.5 Ga was based on photosystem I, which does not produce O_2 as a byproduct. It is therefore likely that the atmosphere at that time did not contain O_2, and that it was mildly reducing.

The isotopic composition of nitrogen in remains of microfossils 2.7–2.5 Ga and the indication that methanotrophs were active at that time (Hayes, 1994) suggest that photosystem II was in operation, and that molecular oxygen was produced by the biota during the late Archaean. However, a wide range of observations suggests very strongly that oxygen levels in the atmosphere were low, probably in the range of 10^{-3} to 10^{-4} atm, until *c.* 2.25 Ga. (Holland, 1994; Holland and Rye, 1997; Rye and Holland, in press).

A similarly strong set of observations indicates that P_{O_2} had risen to 0.03 atm by 2.05 Ga. Further increases in P_{O_2} may have occurred 1.9 Ga and during the last 0.2 Ga of the Proterozoic (Kaufman and Knoll, 1995).

It is proposed that the low value of P_{O_2} between the development of photosystem II and *c.* 2.25 Ga was due to a negative feedback between oxygen concentration and combined nitrogen in seawater at low values of P_{O_2}. The dramatic increase in P_{O_2} may be due to the positive feedback between oxygen concentration and combined nitrogen in seawater at moderate and high values of P_{O_2}. The stabilization of P_{O_2} at its current high value is probably due to the operation of the marine phosphate cycle.

References

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