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Linking the rise of atmospheric oxygen to growth in the continental phosphorus inventory

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The concentration of atmospheric oxygen (pO_2) is thought to have increased throughout Earth history, punctuated by rapid increases ca. 2.4 and 0.8 billion years ago near the beginning and end of the Proterozoic Eon. As photosynthesis is the largest source of free O_2, the reigning paradigm of rising O_2 levels centres around biologic metabolism. Here we show that the phosphorus content of igneous rocks correlates, in a first-order sense, with secular increases in O_2 through time, suggesting that rising O_2 levels are affected by long-term mantle cooling and its effect on the continental phosphorus inventory. Because phosphorus is the limiting nutrient for primary productivity, its availability has fundamental control over the efficiency of oxygenic photosynthesis, pointing to a previously unrecognized role of the solid Earth in biologic and atmospheric evolution. Furthermore, as many bioessential elements are effectively incompatible in the mantle, this relationship has implications for any terrestrial planet. All planets will cool, and those with efficient plate tectonic convection will cool more rapidly. We are left concluding that the speed of such cooling may affect the rate and pattern of biological evolution on any habitable planet.