A BIFURCATION MODEL FOR THE EVOLUTION OF ATMOSPHERIC OXYGEN DURING THE LATE NEOPROTEROZOIC

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Isotopic evidence of perturbations in the carbon cycle, along with the fossil record of primitive animals, suggest that significant changes in atmospheric oxygen took place during the late Neoproterozoic. d13C data from marine carbonates show a pronounced positive excursion in strata post-dating the Varanger (ca. 590 Ma) glaciation. At the same time, rapidly increasing 87Sr/86Sr values in marine carbonates suggest increasing erosion rates related to the Pan-African orogeny. Mass balance calculations combining the Sr and C isotopic data show that this relatively brief (* 10 Ma) interval represents a period of significant net growth of the sedimentary organic carbon reservoir and flux of O2 to the atmosphere. A surface-controlled model of oxidative weathering rates of kerogen is combined with information on carbon burial to develop a dynamic model for the carbon-oxygen system. Oxidative weathering rates depend positively both on the rate of exposure of fresh rock surfaces and on the partial pressure of O2. A model incorporating such a non-linear feedback shows two steady states of atmospheric oxygen. At low pO2, oxygen levels are buffered by interactions with reduced volatiles as well as weathering. At high pO2, the oxidative weathering feedback weak, and pO2 is buffered by other mechanisms. The transition between the two steady states occurs rapidly in response to a perturbation in oxygen production. A threshold response of a nonlinear system appears to characterize the behavior of the C-O system during the Vendian, with direct impacts on biological evolution.