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$\delta^{238}\text{U}$ in organic-rich marine and lake sediment suggest surface oxygenation at 3.0 Ga

WANG, X.¹, FRANTZ OSSA OSSA, PLANAVSKY, N.J.²

¹University of South Alabama; Dauphin Island Sea Lab, USA, xiangli.wang@yale.edu

²University of Johannesburg, South Africa

³Yale University, USA

The timing of the onset of oxygenic photosynthesis is still debated, with current estimates spanning over one billion years. A previous study combining trace element, iron isotope, and U-Th-Pb geochronology suggests a stratified 3.2 Ga ocean, with slightly oxygenated surface ocean and a completely anoxic deep ocean (Satkoski et al., 2015). Statistical treatment of previous and new U isotope data shows a detectable transition in uranium isotope systematics at around 2.95 Ga, suggesting a sizable shift in oxidative weathering on Earth's surface. In particular, several samples from the Sinqeni Iron formation in the Pongola Supergroup yielded fractionated $\delta^{238}\text{U}$ (Wang et al., 2017). Signs of oxygenation at 2.95 Ga were also suggested by previous Cr and Mo isotope studies (Crowe et al., 2013; Planavsky et al., 2014). To better constrain Earth's surface oxygenation at 2.95 Ga, we measured the $\delta^{238}\text{U}$ of the authigenic component of a suite of well-preserved organic-rich, shallow-deep marine sedimentary rocks in the Pongola Supergroup. We found a range of $\delta^{238}\text{U}$ in shallow-deep marine sediments and terrestrial lake sediments (-0.31‰ to -0.68‰). These results suggest that at least terrestrial and shallow marine water bodies contain appreciable amount of dissolved U(VI) derived from oxidative weathering, supporting the hypothesis that biological oxygen production likely occurred at ca. 3.0 Ga. The most parsimonious explanation for the isotopically light deep marine sediments is adsorption of U(VI) to sinking particles in surface ocean.

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