Variable and elevated oxygen in the Archean atmosphere

JEFFREY A. STEADMAN[1], ROSS R. LARGE[1], NIGEL J. BLAMEY[2], ROSS CORKREY[3], AND LEONID V. DANYUSHEVSKY[1]

[1]CODES (Centre for Ore Deposit and Earth Sciences), University of Tasmania, Private Bag 79, Hobart TAS 7001, Australia; [2]Department of Earth Sciences, Western University, London ON N6A 5B7, Canada; [3]Tasmanian Institute of Agriculture, University of Tasmania, Private Bag 98, Hobart TAS 7001, Australia

Current estimates of atmospheric oxygen concentrations in the geologic past indicate that the Archean atmosphere was strongly depleted in oxygen (<0.002 % O_2, or <0.01 % of the present atmospheric level [PAL]; [1]). These figures were determined by both geological observations and a series of geochemical proxies involving redox-sensitive trace elements in whole-rock samples of marine carbonaceous shale and/or their isotopic ratios [2, 3]. However, these proxy techniques have fundamental problems, including a lack of control on isotopic resetting and element deportment.

The use of sedimentary pyrite as a proxy for ocean and atmosphere oxygenation is a novel technique that offers distinct advantages over the standard methods of whole-rock geochemistry and stable isotopes. For example, Se and Co are important redox-sensitive trace elements that predominantly reside in pyrite. LA-ICPMS allows for the selective analysis of Se- and Co-bearing pyrite, which amplifies the signal of these low-level elements [4].

Our data [5] indicate that oxygen rose overall throughout the Paleo-, Meso-, and Neoarchean, from a low of 0.27 % O_2 (1 % PAL) at 3500 Ma to a high of ~5 % O_2 at the Archean-Proterozoic boundary (2500 Ma; 25 % PAL). Multiple decreases in O_2 concentrations also occurred at set times, with the largest drop at ~2900 Ma (down to 0.2 % O_2, or 1 % PAL).

[1] Lyons et al. (2014), *Nature* 506, 307-315. [2] Cloud (1973), *Econ. Geol.* 68, 1135-1143. [3] Bekker et al. (2004), *Nature* 427, 117-120. [4] Large et al. (2014), *EPSL* 389, 209-220. [5] Steadman et al. (2020), *Precam. Res.*, in press.