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Direct constraints on the composition of the ancient atmosphere from fluid inclusions in surficial minerals at key intervals of Earth's history

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Proxies for the composition of the ancient atmosphere are inaccurate and rarely quantitative. Estimates of pCO_2 and pO_2 in Earth's deep past are particularly poorly constrained; in periods as recent as the Mesozoic, atmospheric pO_2 estimates disagree by 50%. We address this conundrum by quantifying the contents of fluid inclusions in minerals formed in surficial environments that capture geochemical snapshots of the overlying atmosphere. We developed an analytical technique whereby inclusions are mechanically decrepitated and contents released directly into a quadrupole mass spectrometer [1]. In addition, a gas-aqueous partition based on measured N_2/Ar ratios provides a method for determining the atmospheric gas composition that equilibrated with aqueous fluid prior to entrapment. We examine three mineral systems from two case studies – the Mesoproterozoic 'boring billion' (~1.4 Ga), and the End Triassic Extinction (ETE) that is temporally associated with the eruption of the Central Atlantic Magmatic Province (CAMP, ca. 201.5 Ma). Lacustrine halite from the Sibley group (Ontario Canada) provides a snapshot of the Mesoproterozoic atmosphere from the 1.443 Ga Outan Island Formation, which we find was dominated by N_2 and contained 23.8 ± 15.7 mbar O_2, and 3.82 ± 1.41 mbar CO_2 [2]. The high pO_2 coincides with the diversification of plastid-bearing eukaryotes (red algae), and moderate CO_2 density indicates Earth's climate was warm enough to avoid global glaciation. In the Triassic we find coherence of atmospheric gas concentrations measured from inclusions in deep marine and palustrine cherts and paleosol carbonates. Remarkably, these determinations from three contemporaneous but geographically disparate depositional regimes converge on single values for atmospheric pCO_2 and pO_2. Moreover, both the marine and terrestrial realms show a contemporaneous increase in pCO_2 coincident with the emplacement of the initial pulse of CAMP lavas and the ETE [3]. In addition, argon isotope analyses of the Triassic cherts reveal significant radiogenic Ar, indicating that the entrapped gas is indeed ancient.

1. Pettitt E.A., Schaller M.F., (2020), Rapid Comm. Mass Spec., doi.org/10.1002/rcm.8855
2. Park J.G., Shelley J.T., Schaller M.F., AGU Fall Meeting, 2023
3. Hudgins, M.N., Ikeda, M., Olsen, P.E., Schaller, M.F., AGU Fall Meeting, 2023