Atmospheric and oceanic oxygen at 1.4 Ga measured in halite

BLAMEY, N.J.F.[1,2,3], BRAND, U.[1], FRALICK, P.[4], LÉCUYER, C.[5], BENISON, K.[6], PARNELL, J.[3]

[1]Department of Earth Sciences, Brock University, 1812 Sir Isaac Brock Way, St Catharines, ON L2S 3A1, CANADA; nblamey@brocku.ca ubrand@brocku.ca
[2]New Mexico Institute of Mining and Technology, Socorro, NM 87801, U.S.A. [3]Univ of Aberdeen, Aberdeen, AB24 3UE Scotland, U.K. [4]Lakehead Univ, Thunder Bay, ON P7B 5E1, CANADA [5]Univ of Lyon and Institut Universitaire de France, 69622 Villeurbanne, FRANCE [6]West Virginia Univ, Morgantown, WV 26506, U.S.A.

Halite recently gained interest as a host for studying ancient atmospheric oxygen levels owing to primary fluid inclusions that trap atmosphere as the mineral precipitates at the water-atmosphere interface (Blamey et al., 2016). Unlike indirect geochemical approaches that are not calibrated to the atmosphere, analysis of inclusion gases by mass spectrometry provides a direct method to quantify atmospheric oxygen.

Samples were recovered from drill core that intersected the 1.4 Ga Outan Island Formation in Ontario. Petrography provides the most robust screening to identify primary and secondary inclusions. Only parts of the sample are recovered for gas analysis and the hand picked pieces are cleaned in isopropanol and air dried. Pieces are incrementally crushed under high vacuum and the released gases are analysed by mass spectrometry. We report on N_2, O_2 and Ar gases and results are normalised to the sum total.

The pO_2 concentration ranges from 2.1 to 3.2 % with the balance primarily N_2. This translates into 10-15 % of present atmospheric levels (PAL). Argon ranges from 0.39 to 0.61 % whereas in modern atmospheric air it is 0.934 %.

Blamey et al. (2016) reported atmospheric pO_2 during the Neoproterozoic of about 10.9 %, and this study pushes back measurements of pO_2 by about 600 Ma. Several papers provide estimates of atmospheric O_2 levels based on RSE's of Cr isotopes with ranges of <0.1 to 15 % PAL. Zhang et al. (2016) suggested that atmospheric O_2 was 3.8-6.2 % PAL at 1.4 Ga based on Cr isotopes. Based on TOC they also calculated O_2 levels of 8-15 % PAL during deposition of the Xiamaling Formation that match our results.

Atmospheric pO_2 levels were about 2.5 % by 1.4 Ga although shallow and deep ocean waters were dysoxic and anoxic, respectively. The O_2 values could help unravel the evolution of life during the Mesoproterozoic.

Blamey, N.J.F., Brand, U., et al. 2016. Geology, v. 44, p. 651-654.

Zhang, et al. 2016. PNAS, v. 113, p. 1731-1736.