Neoproterozoic atmospheric oxygen and the diversification of M-A life

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We present analytical results of H_2, CH_4, N_2, O_2, Ar and CO_2 measured by mass spectrometry on Neoproterozoic halite inclusions. We use a robust method [1] to analyse gas inclusions (GI) in geologic materials of all ages for procuring direct measurements of gas contents in terrestrial seawater and the atmosphere. Samples may be as small as 25 mg and inclusions as small as 1 micron. The small sample and gas inclusion sizes minimize problems of cross contamination and give gas contents with greater homogeneity. Acquisition of gases is achieved with two quadrupole mass spectrometers (Pfeiffer Prisma^{TM}) operating in the fast-scan, peak-hopping mode. Detection limits with mass spectrometry for most inorganic gas species is about 0.2 ppm (about 1 femto mol). The novel procedure allows us to routinely determine: H_2, He, CH_4, N_2, O_2, H_2S, Ar, CO_2 and H_2O. Accuracy of gases in artificial inclusions is ~0.5%, and precision for major gases is ~ 5% in natural materials.

Neoproteorozoic chevron halites from the Brown Formation of the Officer Basin, Australia are dated at 838 to 835 m.y. old, and are considered well preserved with primary chemistry. Fluids from inclusions suggest that marine sulfate was 10% of modern concentrations, while gas inclusions contain water, N_2, O_2, Ar, CO_2 and trace amounts of He and CH_4. The O_2/Ar ratios of the halites from two wells covering the Brown Formation vary from 11.4 to 13.6, which is about 50-60 % of the modern atmospheric O_2/Ar ratio of 22.4. This level of atmospheric O_2 measured for the mid-Neoproterozoic Cryogenian is higher than anticipated by most authors, but compares well with the onset and postulated increase proposed by Holland (2006). Thus, adequate oxygen was present in the atmosphere and oceans facilitating the explosion of life during the Ediacaran and Paleozoic.

The 'high' level of measured atmospheric O_2 (50-60% PAL) unequivocally corresponds to the great diversification of metazoan and algal life during the second GO-MAD (2 Great Oxidation & Metazoan-Algal Diversification) event of the Proterozoic.

[1] Blamey et al. (2015.) Nature Communications (in press). Holland, H.D. 2006. *Phil. Trans. R.Soc.* **361**: 903-915.