Measuring paleoatmospheric terrestrial and martian gases

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We present analyses for H_2, CH_4, N_2, O_2, Ar and CO_2 measured by mass spectrometry from Neoproterozoic halite as well as martian meteorites inclusions. We use a robust method (Blamey et al., in press) to analyse gas inclusions (GI) in geologic materials for procuring direct measurements of gas contents in terrestrial seawater and the atmosphere, and in meteoric, diagenetic, hydrothermal and martian meteorites. This applies equally to terrestrial (TE) and extraterrestrial (ET) materials of all ages. We are able to obtain gases from samples as small as 25 mg, hosting groups of inclusions as small as 1 micron, using the incremental crush and fast scan (ICFS) method at room temperature. The small sample and gas inclusion sizes minimize problems of cross contamination and thus give gas contents with greater homogeneity, and more importantly, avoid many of the pitfalls experienced by other fluid inclusion gas methods. Acquisition of gases is achieved with two quadrupole mass spectrometers (Pfeiffer Prisma™) 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), and slightly higher for organic species. The novel procedure allows us to determine routinely the following: 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.

Martian Nahklites contain CH_4, H_2, N_2, Ar, CO_2, and martian Shergotites contain these gases and free water. The presence of CH_4, N_2 and H_2O are necessary and fundamental building blocks for the evolution and to the existence of life on Earth and Mars.

Neoproteorozoic chevron halites from the Browne Formation, Australia, contain water, N_2, O_2, Ar, CO_2 and trace amounts of He and CH_4. Whereas the modern atmospheric O_2/Ar ratio is 22.4, halite fluid inclusion O_2/Ar ratios vary from 11.4 to 13.6, implying that O_2 levels during the early-mid Neoproterozoic were 50-60% of present oxygen levels. Adequate oxygen was present in the atmosphere and oceans facilitating the explosion of life during the Ediacaran and major diversification during the Paleozoic.