Measuring atmospheric and marine hydrospheric gases of Earth & the Martian subsurface

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We present a novel process that analyses gas inclusions (GI) in geologic materials for procuring direct measurements of gas contents in seawater and the atmosphere, and in meteoric, diagenetic, hydrothermal and magmatic fluids. 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 minimizes problems of cross contamination and thus gives gas contents with greater homogeneity, and more importantly, avoids many of the pitfalls experienced by other fluid inclusion gas methods. 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, 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, as well as C_2H_4, C_2H_6, SO_2, C_3H_6, C_3H_8, C_4H_8, C_4H_{10}, and C_6H_6. Accuracy of gases in artificial inclusions is ~0.5%, and precision for major gases is ~ 5% and ~ 10% for minor species in natural materials. In addition, the cryogenic trapping of the primary H_2O allows for the separate analysis of $\delta^{18}O$ and δD compositions.

Our method allows for the chemical characterization of dissolved gases in biogenic carbonates, ancient seawater – and as such – the gas content of the overlying atmosphere.