Global Inventory of Natural Gas Molecular and Isotopic Compositions

O.A. Sherwood[1], S. Schwietzke[2,3], G. Etiope[4] and J.B. Miller[3]

[1]Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder, CO 80309; 720-320-6245, E-mail: owen.sherwood@colorado.edu
[2]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO 80309
[3]NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO 80305
[4]Istituto Nazionale di Geofisica e Vulcanologia INGV, Rome 605 00143, Italy

Top-down models of the global atmospheric methane budget use isotopic and/or molecular data to constrain source-specific emissions. These models are sensitive to end-member signatures (delta-$^{13}C_{CH4}$, delta-D_{CH4}, ethane:methane ratios) for the three main source categories, microbial methanogenesis, biomass burning, and fossil fuels. However, the end-member values are poorly constrained and based on data of unknown or limited sample count, regional extent and global representation. For fossil fuels in particular, few modeling studies reference primary data, despite a vast literature in petroleum geology reporting on the isotopic and molecular composition of natural gas. To address this problem, we compiled a database of 8,734 natural gas analyses from peer-reviewed literature, government reports and databases, with data on the molecular (C_1-C_6) and isotopic delta-$^{13}C_{C1-C5}$ and delta-D_{C1-C5} composition of conventional oil and gas, coal and shale gas. The data comprise 45 countries, representing 82% of global natural gas production and 80% of global coal production. Raw delta-$^{13}C_{CH4}$ values averaged -44.0 ± 0.1 ‰ (1 STDERR., n = 6080) for conventional oil and gas, -49.5 ± 0.3‰ (n = 1402) for coal, and -42.5 ± 0.3‰ (n = 646) for shale gas. All three categories of fossil fuel have left-skewed or bimodal delta-$^{13}C_{CH4}$ distributions, reflecting microbial methanogenesis in a significant fraction of the world's oil- and gas-producing reservoirs (e.g. giant Cenomanian gas fields of western Siberia), and in relatively shallow coal-bearing formations. These fossil-fuel end-member values have significant implications for top-down models of regional and global methane budgets. The database will be published in the public domain.

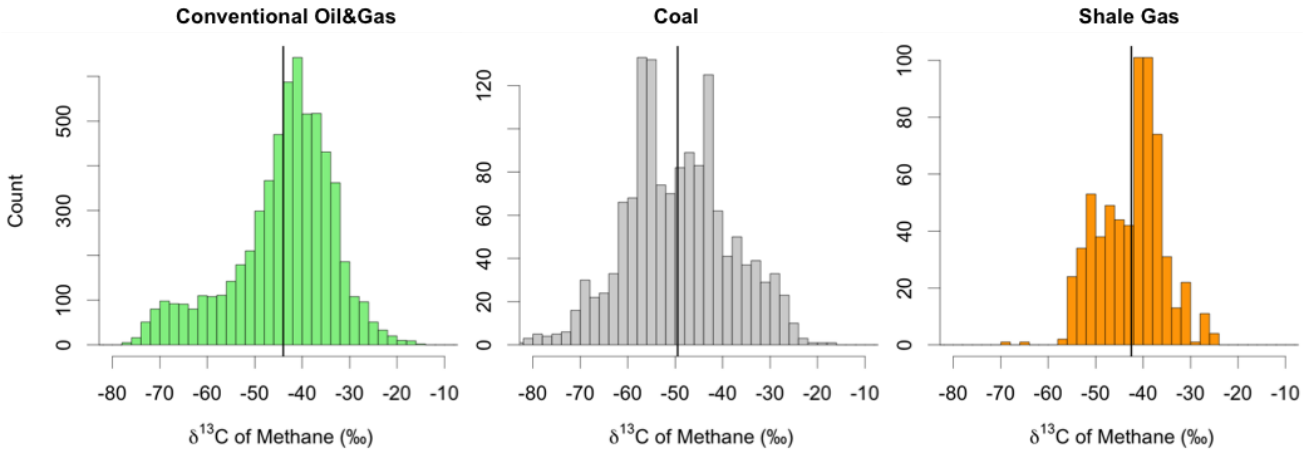

Figure 1. Histograms of the delta-$^{13}C_{CH4}$ of conventional oil&gas, coal and shale gas from the global database. Vertical lines represent mean values for each category.