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Please fill in your manuscript title.	Origin of nitrogen and carbon dioxide in natural gas: implications for the risk of high N_2 exploration in siliciclastic and carbonate formations

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Abstract

Scope / Objective

Understanding the origin of non-hydrocarbons encountered in the exploration and production process is crucial to reduce the investment risks and help resolving the geological challenges in the subsurface. Nitrogen (N_2) and (CO_2) are two of the most common non-hydrocarbons in natural gas. The investigation of the N_2 and CO_2 origin and content changes will help to provide geochemical evidence for predicting the gas quality and types prior to drilling.

Methods

In this study, gas compositional analysis and carbon isotope are used to assess the origin and the distribution of both N_2 and CO_2 in siliciclastic formations.

Results/discussion

The results display that N_2 content vary widely (0.1-7 mole, %) in the siliciclastic formation. Based on the N_2 content and the carbon isotopic composition of hydrocarbons, we have classified the natural gases found the siliciclastic intervals into three genetic types: (I) oil-associated gas with high N_2 content, (II) dry gas with low N_2 content, and (III) mixed gas with intermediate content of N_2. The carbon isotopic composition values of CO_2 ($\delta^{13}C_{CO2}$) for the three groups are distinguishable and correlate well with the N_2 contents. Oil-associated gas group is characterized by depleted ^{13}C values (-13 to -7‰) for $\delta^{13}C_{CO2}$, suggesting an organic CO2 source. In contrast, the dry gas with low N_2 content is characterized enriched ^{13}C values (-3 to 2‰) for $\delta^{13}C_{CO2}$, suggesting an inorganic CO2 source. Group (III) shows is characterized by intermediate $\delta^{13}C_{CO2}$ values, which also indicate the presence of mixing between the two end-member of gases (i.e., groups 1 and 2). Our geochemical and geological data suggest that a deep N_2 gas source in not relevant. Therefore, high N_2 concentration could be originated from the decomposition of organic matter at high mature stage and/or it could be derived from ammonium clays.

For the studied carbonate interval, we have classified the natural gases into dry gas with high N_2 contents. The carbon isotopic compositions measured from the dry gases with high N_2 contents are extremely enriched in ^{13}C for methane and depleted in ^{13}C for the CO_2, suggesting an alteration by thermochemical sulfate reduction. High N_2 content in the dry gas is directly associated with the destruction of methane via TSR and the precipitation of H_2S as ZnS and PbS. Further data from the nitrogen isotopic composition is needed to better determine the origin of high nitrogen.

Novelty

This study has an important application in determining the origin of non-hydrocarbons, which can directly affect the prediction of the quality of gas in the subsurface.