

CO₂ Hydrate Formation Heat Release as a New Tool to Melt In Situ Methane Hydrates

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We suggest a new method of the natural gas hydrate exploitation by injection of carbon dioxide into the gas hydrate deposits. The method is based on heating and melting of the natural gas hydrate by the heat released during formation of the carbon dioxide hydrate after CO₂ injection into the natural gas deposit. In Arctic sub-permafrost or offshore the subsurface temperature or sub-bottom temperature are commonly below the stability curves both for natural gas and carbon dioxide hydrates (see Canada; Majorowicz and Osadetz, 2001, AAPG 85(7)). In case of CO₂ injection the heat released during the crystallization into CO₂ hydrate warms up the medium, including the natural gas hydrate. In the moment, when the local temperature reaches the stability temperature of the natural gas hydrate (lower than that of the CO₂ hydrate for depths down to some 1km), the temperature stops to increase and the heat from ongoing CO₂ hydrate crystallization is consumed in melting of the natural gas hydrate. The released natural gas can be pumped out. Only when all the natural gas hydrate is melted, the temperature resumes growing. To secure a safe storage of CO₂ in a form of the solid phase, further CO₂ injection must be stopped before reaching the CO₂ hydrate stability temperature. It is shown for a typical case, using the calorimetric equation, that after CO₂ hydrate formation in about a quarter of the pore space not occupied by the natural gas hydrate, the released heat is large enough to warm up the whole medium by 5 K at some 0.85 km and hence to rise temperature to the melting temperature of the natural gas hydrate. The CO₂ injection into and the CO₂ hydrate formation within the remaining pore space not occupied by the natural gas hydrate can continue, but all the released heat is consumed by the natural gas hydrate melting and the temperature does not grow now. Because the crystallization heats and densities of the natural gas hydrate and of the CO₂ hydrate are similar, the CO₂ hydrate formation in a certain fraction of the pore space will be compensated by the natural gas hydrate decay in another fraction of the pore space of the similar volume. This volume will be available for further CO₂ storage. Therefore, in this case study, it would be possible to melt all the natural gas hydrate (and to pump out all the released natural gas) by injecting carbon dioxide into about 70% of the pore space.