POTENTIAL EFFECTS OF METHANE HYDRATES TO THE ENVIRONMENT

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ABSTRACT

During the past 50 years, there has been a growing awareness of environmental issues related with energy technologies and natural resource utilization. A growing global population demands augmenting amounts of energy, goods without big discovery of conventional resources (apart from Zohr offshore field in Mediterranean Sea-Egypt), leading companies and countries turn their interest in unconventional resources such as shale oil, shale gas, and gas hydrates. Although gas hydrates are considered as one of the alternative energy sources of the future, they exhibit possible environmental risks for both marine ecosystem and atmosphere environment. This paper presents the instability of methane hydrate that either takes place naturally or be triggered by anthropogenic activities. Furthermore, it explains the climate changed (methane released to the atmosphere has 21 times more global warming potential than carbon dioxide) and the ocean acidification (more than 50% of dissolved methane retains inside seafloor by microbial anaerobic oxidation of methane) caused by methane hydrate release. Moreover, it presents the seafloor instability when methane hydrated block sediments due to augmentation of temperature or pressure drop. Finally yet importantly environmental risks and hazards during the process of production and drilling hydrate reservoirs occupy a significant position in the presentation of this research.

INTRODUCTION

There are two assured things about gas hydrates worldwide; there are many gas hydrate reservoirs especially in marine environments and there is precariousness about the quantity of them [1,2]. Natural Gas Hydrates (NGH) are solid clathrate compounds where water forms a cage-like structure around small size gas molecules [3, 4]. A clathrate is a chemical substance consisting of a lattice that traps or contains molecules. Natural Gas Hydrates are non-stoichiometric solid compounds and they are formed when the constituents come into contact at high pressure and low temperature [5]. In 1778, Sir Joseph Priestley produced the first factitious hydrates. Sir Priestley noticed that there was enhanced "ice" configuration during the time that cold water was come into association with sulphur dioxide [6]. After 20 years in 1810 Sir Humphry Davy reported on chlorine hydrates as a form of solid water. Davy's assistant, Michael Faraday also examined the hydrate of chlorine and in 1823; he mentioned the composition of the chlorine hydrate. Even if, his outcome was not correct, it was the initial attempt of measuring the composition of a gas hydrate [7]. As far as gas hydrates reservoirs considered, the Russian scientists measured big quantities of methane rich gas hydrate supposedly existed in both permafrost and marine regions. The first gas hydrate field was discovered in Siberian permafrost and then followed by discoveries in Caspian and Black Sea in 1974 [6]. Recycling on the gas molecules are present, hydrates form different crystal structures. Cubic structure I (sI) and structure II (sII) and hexagonal structure H (sH) are the three-gas hydrate structures. CH_4 (methane), C_2H_6 (ethane), H_2S (hydrogen sulfide) and carbon dioxide (CO_2) form structure I hydrate, while C_3H_8 (propane) and N_2 (nitrogen) form structure II hydrate [8]. Hydrates are regarded as a huge source of natural gas, because one-unit volume of solid gas hydrates comprises a quantity of gas, which is 150–170 times higher at standard conditions [9]. Gas hydrates are widespread in ocean sediments hundreds of meters beneath the seabed along the continental margins, as well as in Arctic permafrost [10]. Max and Johnson (2016) claimed that most of Gas

Hydrate reservoirs are deposited in marine sediments (at least 95%) while less than 5% of hydrates exist in permafrost location [11]. Contingent reserves of gas hydrates are over 1.5×10^{16} m^3 and are distributed all over the earth both offshore and onshore. If only 17-20% of this resource is produced, it can be adequate to supply energy for 200 years [12]. Figure 2 represents the estimation of quantity of gas hydrates through years

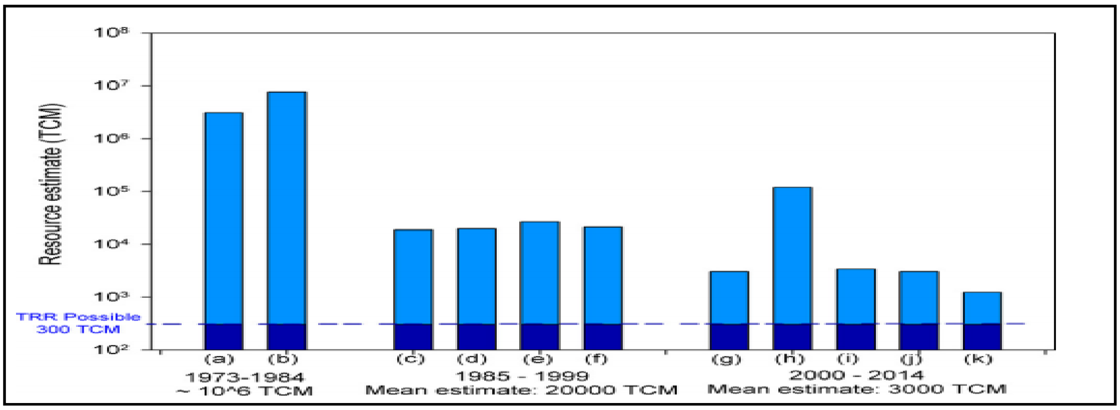

Figure 1. *Resource estimation of hydrates [13]*

ENVIRONMENTAL IMPACTS OF GAS HYDRATES

In the last decades, the attention of both scientific and political community on climate change has augmented [14]. Marine ecosystems have accepted environmental impacts due to decrease of oxygen concentration dissolved and the augmentation of sea temperature [15]. It is obvious that until gas hydrates become an attainable energy source, it will be needed to overcome different present difficulties [14]. Any try of production test of gas hydrates could be a contingent danger for both marine and atmospheric environment [16]. The process of releasing methane gas from hydrate in either marine environment or to the atmosphere by anthropogenic actions or natural causes may create environmental impacts. In addition to, the devolution into gas from solid phase gas hydrates and the continued reduced aid to the sand grains that take place in the surroundings, it creates seafloor instability and sometimes-submarine landslides [17]. The augmentation of temperature for some degrees in the bottom of the ocean may have such an outcome. The increase in the temperature of sea bottom may lead in an outcome such as climate change in the environment, guiding to crucial quantities of released methane from gas hydrates [18]. Except for temperature alterations in the bottom of the sea, the sea circulation also promotes the release of methane from gas hydrates [19]. The bottom of the sea has around 100-1000 years of ventilation (long times); therefore a novel balance of methane hydrate can be created in 1000-10,000 years. On the other hand, methane's fraction that transported from bottom of the sea to the epiphany is unstable and depends on bubble's transportation process [20]. Methane hydrates may have influence in climate change, seafloor instability and ocean acidification. Methane has the potential to affect global warming 21 times more compared to carbon dioxide [21]. Because of the higher quantity of carbon dioxide in comparison to methane in the environment, methane's infrared radiation absorption bands are less saturated [22]. The formation of gas hydrates is succeeded through decomposition of organic compounds accumulated from process of photosynthesis both in the sea and on permafrost's. Because of not stable conduct of methane hydrates underneath earth, they have an inclination to be released easily. Abrupt release of big quantities of methane may cause climate alterations. Actions could be taken; firstly, to audit the escape of methane from hydrates and secondly to capture gas released, for the removal of the phenomenon of global warming [23].

Methane's release in sea areas might lead to acidulation and decrease of oxygen. More than half of methane, that is dissolved in seawater; it can be maintained inside seabed by microbial anaerobic

oxidation of methane (AOM) [24]. Thereafter, methane and oxygen are transformed by (AOM) into carbon dioxide which is the main factor causing change in the pH of sea [25]. Both carbon dioxide originating by human activity and induced methane can impair the sea acidulation [26]. Sea acidulation can enforce negative effects on sea ecosystem. For instance, the reduction of pH may affect the pollination and reproduction of sea species. Shellfish such as oyster, clams and corals can be influenced by higher partial pressure of carbon dioxide [27].
When methane hydrate is formed, both methane and water are together within the sediment pore spaces. Forces are created to the sediment because of inability of water to get away from a consolidate sediment. As an outcome of either augmentation of temperature or reduction of pressure, methane gets erratic and blocks the sediment. The sediment is 'cemented' by methane hydrates and concludes erratic as an outcome of temperature increase and change of pressure. Afterwards, the releasing methane will lead to a layer with low shear force [28]. As an outcome, there may be a seismic activity below seabed, production of submarine landslides due to seafloor deformation and even a tsunami. Furthermore, it is supported that every mass failure produced by catastrophe of continental slope is correlated with one or another way with reduction of sea level due to climate change. The quick reduction of sea level creates instability to gas hydrate reservoirs and this leads to triggering the slope malfunction and the glacial mass transport of deposits [29]. It is known that a slope is more sensitive to be influenced firstly by augmentation in thermal diffusivity and hydrate saturation and secondly by reductions in water depth, gas saturation and pressure diffusivity [30]. Moreover, in hydrate reservoirs in ocean, the decrease of sea's levels could lead to segregation between sediments and gas hydrates, which in turn could resist the release of big quantities of gas into sediment; increasing the pore fluid pressure and diminishing slope firmness [31].

GAS HYDRATES AND DRILLING OPERATIONS

Nowadays worldwide, there is quite enough knowledge about drilling conventional gas and oil wells both in shoreward and seaward environment. Nevertheless, try to drill a gas hydrate well needs knowledge, which is not existent yet. Researchers and engineers should estimate how to drill a gas hydrate well without enough features. Hence, it is obvious that the process of drilling gas hydrate reservoirs may be hazardous. Some of the most important dangers are observed: 1) when hydrate is formed and blocks the borehole, 2) when gas hydrates are dissociated abruptly, it creates blowout, 3) when gas hydrates are dissociated abruptly, there is danger of slope failure, 4) when gas hydrates are dissociated there is difficulty both in stability of wellbore and danger in wellbore subsidence because of the loose sediments [32]. When the procedure of drilling starts, the management of temperature and pressure in the wellbore must be audited to limit reservoir's hydrates dissociation together with annulus mud. Another challenge during drilling operations in hydrate reservoirs is the correct casing design to resist in high values of pressure. Furthermore, when fracture gradient and pore pressure is very close (there is limited window margins), there is high possibility for kick or formation fracture risks, which lead to collapse of the well. Finally yet importantly, in drilling operations in gas hydrate reservoirs there must be frequent well control for gas kick circulation or abrupt gas flow for unconsolidated formation [33]. All these challenges may create huge environmental problems especially in offshore locations (95% of hydrate reservoirs) with countless consequences on the sea chain.

CONCLUSION

Natural gas hydrates may be both considered as a promising future energy source and a possible contributor to the global climate change. The relationship between gas hydrates and climate is not clear, however in geological history, there were clear facts showing that high amount release of methane gas from hydrates had a probable potent effect on global climate. This fact can be easily understood. Although, the residence time of gas hydrate release is limited in the atmosphere over the lifetime, methane as gas compared to carbon dioxide is around 20 times more effective in terms of its total greenhouse contamination. Moreover, the ongoing methane release in sea environments may be spliced to alter the climate with the objection that the historical data of these inferences is little and needs verifications.

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