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Exploration of Gas Hydrate and the present global scenario

What is Gas hydrate

The worldwide amount of carbon, bound in gas hydrates, is conservatively estimated to be a total of twice the amount of carbon to be found in all known fossil fuel on earth. The extraction of methane from hydrates could provide an enormous energy and petroleum feedstock resource. Moreover conventional gas resources are believed to be trapped beneath methane layers in ocean sediments. So gas hydrates can be considered for an unconventional energy resource for our future.

Gas hydrates (GHs) are a vast energy resource with global distribution in the permafrost and in the oceans. After a brief examination of GH accumulations that are well characterized and appear to be models to future development and gas production, scientists have analyzed the role of numerical simulation in the assessment of the hydrate production potential, identified the data needs for reliable predictions, evaluated the status of knowledge with regards to these needs, discussed knowledge gaps and their impact, and reached the conclusion that the numerical simulation capabilities are quite advanced and that the related gaps either are not significant or are being addressed.

In natural setting, such as the ocean bottom, when buried organic matter decomposes to methane and dissolves in water, clathrates form at temperature greater than 277 K (4° C or 39° F). Biogenically produced methane, in dissolved water, forms hydrates very slowly because of mass-transfer limitations. Over geologic time, the total enclathrated methane in the oceans has been estimated 2.1 *10⁶ standard cubic meters (SCM)- twice the energy total of all other fossil fuels on earth. The amount of hydrated methane in the northern latitude permafrost is relatively small (7.4 * 10¹⁴ SCM), within the error margin of ocean hydrate estimates

What is the Chemistry behind it:-

The Crystalline solids of Clathrates are formed under moderate pressure and temperature, but above freezing point of water in nature. These solids are very hard and ice-like, and may contain molecules of substances other than methane. Let us compare the properties of pure hydrates and the other water-saturated sediments.

Property	Hydrates	Water Saturated Sediments(AVG)
Acoustic vel i.e. vp (km/sec)	3.6	1.5. - 2.0
Transit time (msec/ft)	84.7	203 - 152
App.Resistivity in ohm-mt.	150	1 - 3
App.Bulk density in gms/ cm ³	1.04 - 1.06	1.75

Neutron Porosity in % (Limestone)	50 - 60	70
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Advancement in research and development

The past decade has seen a marked acceleration in GH R & D. Among the most important developments is the increasing focus of research on gas hydrate bearing sediments (HBS) rather than crystalline hydrate, the improvements in tools available for sample collection and analysis, the emergence of robust numerical simulation capabilities, and the transition of GH resource assessment from in-place estimates to potential recoverability (Boswell 2007).

A fuller understanding of complexities of GH geological system has emerged, including the new insights into the effects of solubility, salinity and heat flow, reservoir lithology, and rates and migration pathways of both gas and H₂O (Ruppel et al 2005; Paul et al 2005). These new data led to a GH resource assessment in the Gulf of Mexico (currently underway) by the US mineral management service of the US department of interior (Ray 2005; Frye et al 2008). Additionally, critical data gaps, such as information on the mechanical and hydraulic properties of HBS needs to be addressed. Significant inroads have been made into our understanding of hydrate response under different production scenarios.

Because the atmosphere warmed by 4° F with shallow oceans in the late Paleocene (55 million years ago), there is evidence for the hypothesis of Dickens *et al* that ocean methane hydrate dissociation caused a large green house gas warming of 14° F, significantly impacting evolutionary process. Atmospheric-induced changes in the ocean floor temperature are not likely to occur in current times because deeper oceans effectively constrain temperature changes. Such factors as geologic tectonism and warm-ocean-current circulation may contribute to modern ocean hydrate disruption.

Pilot drilling, characterization, and production testing of hydrates have begun in permafrost regions that have higher hydrate concentrations (e.g. 30 Vol % in the 1998 Mallik 2L-38 well in Canada, with a third Mallik well completed in March 2002). These permafrost- Hydrate exploration and production tests will aid the understanding of how to approach the more dispersed, but far larger, ocean resources in future. Finite-difference reservoir recovery models indicate that production is only economic at rates greater than $0.5 * 10^6$ SCM/d.

What the study revealed:-

Study revealed that an estimated 25 quadrillion cubic meters of methane is available in Hydrates globally. Theoretically one cubic centimeter of pure methane hydrate should yield 164 c.c. of methane and 8c.c. of water.

Reservoir rocks contain a greater concentration of methane. For instance in a reservoir with 30% of porosity at a depth of less than 5000ft, one c.ft. of rock generally contains 50

c.ft.of gas in the form of methane

The recovery methods:-

There are three principal energy- recovery methods, viz depressurization, thermal stimulation, and inhibitor injection. The most producible permafrost-hydrate-deposits are those lying in direct contact with a gas reservoir, such that free gas production causes hydrate dissociation by decreasing reservoir pressure below the hydrate stability pressure. Heat from the earth allows hydrate decomposition to slowly replenish the gas reservoir.

Constraints in recovery:-

Unfortunately, because hydrates in ocean sediments are dispersed (typically <30% vol %), substantial effort is required for economic energy recovery. A recent workshop concluded that most critical in-situ issues arise because hydrates are ill-defined in four respects in the geophysical/chemistry domain: detection, distribution, sediment properties and, and hydrate controls. For example, sonic waves are the principal detection tool for ocean hydrate deposit, but some quantification and frequently qualitative detection of hydrate is inadequate, as suggested with BSRS in the Gulf of Mexico. Field tests are required to bind the problem in the field, which will be verified by laboratory experiments.

How to Assess the Environmental hazard:-

Fate of Methane in sea water is not clear. So one has to understand the dynamics, the distribution of methane hydrate first and then quantify its role in the global carbon cycle and climate change.

Safety and sea floor stability:-

Land slide may happen when hydrates break down at its base.

Slides may also occur due to melting of the top of hydrate layer, which is covered by sediment.

Sea floor land sliding occurring from earthquake can also cause break down of hydrates.

Activities in India

1. *D.G.H.* (Director General of Hydrocarbon, India)- survey in deep water of Andaman revealed the gas hydrate prospect in ST-1 to ST-7 at a depth of 800-2000m.

2. *ONGC* (Oil and Natural Gas Corporation, India)- Seismic prospecting of 1400 sq.km area in Krishna-Godavari deep offshore revealed the vital information on Interval Velocity, Polarity, amplitude variation with offset at bottom simulating Reflector (BSR)

level and other Geoscientific information like Bathymetry, structure, thickness of hydrate stability zone(HSZ),rate Of sedimentation etc.

3. *GAIL-NGHP*(National Gas hydrate project)- through CSIR Institutes prepared GHSZ (Gas hydrate stability zone) thickness map in offshore Goa.

4. *NGRI*(National Geophysical Research Institute,India) -Sponsored by GAIL for western and eastern region acquired expertise through wave form Inversion of multi channel seismic data.

5. *NIO*(National Institute of Oceanography,India)- In Western continental margin of India surveyed and observed the presence of acoustic signatures in continental slope and rise region off Goa.

Conclusion:-

Thus gas hydrate can definitely offer alternative energy resource for our future. Much research is still necessary to determine the methodology to extract gas hydrates economically. The following state-of-the-art Geophysical tools can be used for studying the subject.

1. Conventional well logs (resistivity and porosity).
2. High resolution multichannel seismic profiling.
3. Super resolution seismoacoustic profiling.
4. High resolution seismic reflection and refraction tomography (Sounding)
5. Electromagnetic sounding.
6. Deep ocean geophysical penetometry.
7. Geological coring(with onboard determination of core physical properties).