P 413

Gas Hydrates - A New Horizon

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Summary

Gas hydrates are crystalline form of water and methane that form at high pressure and moderately low temperature. They have attracted the global attention due to their natural occurrences; potential as major energy source and role in climate change. It has been estimated that the carbon in gas hydrates is two times the carbon stored in fossil fuel reserves, and thus gas hydrates are considered as a viable source of energy in the 21stcentury. Presence of gas hydrates makes the sediments impervious and hence trap free-gas underneath. Therefore, identification and quantitative assessment of gas hydrates are very essential for evaluating the resource potential and impact of environmental hazard. Gas hydrates, in an area, are mostly recognized by identifying an anomalous reflector, known as the bottom simulating reflector or BSR by seismic experiment .In India , organization and research institutes under Ministry of earth science and the Ministry of Petroleum and Natural Gas, has set three milestones viz., (1) Estimation of gas hydrate and free gas underlying gas hydrate resources in the Indian deep offshore from seismic data, and geological information, (2) Sampling hydrated sediments in identified areas (3) Development of technology and innovations for their exploitation

Challenging part is that there is still no proven technology world over to exploit methane from Gas hydrate on a commercial scale. Moreover since much of the gas hydrate reserves worldwide are found disseminated in sandstone whatever research being done on the extraction of gas from hydrates focus on disseminated deposits in sands. This is in contrast to our discovery of gas hydrates in KG offshore, which are massive in nature and found in fractured shale.

This Paper is concerned with initial step which is been done to exploit/extract Gas Hydrates which can be proposed as future drilling location based on following work:

(a) Locating Gas hydrates in Indian Basin's by Identifying Bottom Simulating Reflector (BSR) and correlating it.

(b) Characterizing most of the recovered gas hydrate as either pore-filling grains, particles disseminated in coarser grain sediments, or as a fracture-filling material in clay-dominated sediments.

(c) Ascertaining that the occurrence of concentrated gas hydrate is mostly controlled by the presence of fractures and/or coarser-grained (mostly sandrich) sediments.

***Keywords**: Bottom simulating reflectors, gas hydrate.*

Introduction

Depletion of fossil fuels that meet ~90% of global energy requirement and growing demand of energy necessitate looking for an alternate form of energy for sustainable development. Among all renewable and nonconventional energy resources, gas hydrates seem to be a viable source of major energy in near future. Gas Hydrates are crystalline substance (Fig.1a) of water and light hydrocarbons (mainly methane), and are formed at high pressure (>500 MPa) and moderately low temperature (< 15OC) in shallow sediments of outer continental Margins and permafrost regions where methane concentration exceeds the solubility limit (Sloan, 1998; Kvenvolden, 1998; Paull and Dillon, 2001; Taylor and Kwan, 2004). Unlike natural gas, oil and minerals, gas hydrates are not stable at standard temperature and pressure (STP). One volume of gas hydrates releases about 164 volume of methane and 0.8 volume of fresh water (Fig.1b). The sediment properties like grain size, porosity and permeability influence the formation of gas hydrates (Buffet and Zatsepina, 2000). The methane in gas hydrates is either biogenic or thermogenic or mixture of these two. Biogenic methane is produced in-situ by bacterial breakdown of copious

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organic matter where rate of sedimentation is high. The thermogenic gas is produced by the maturation of kerogen in petroleum-rich province at much greater depths and higher temperatures, and contains higher molecular weight hydrocarbons. The common crystalline form of gas hydrates is structure-I in which methane is the main constituent.

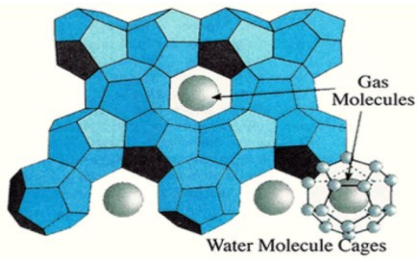
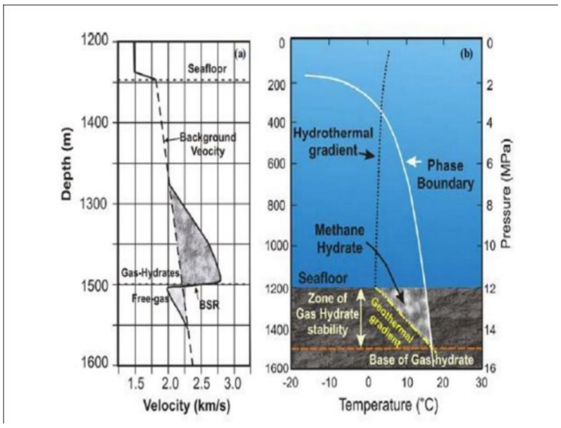


Fig 1. -- (a) Gas hydrate model



Figure(2):(a) Typical 'velocity increase' due to gas hydrates and 'velocity drop' by free-gas across the BSR against the background (without gas hydrates and free gas) trend (b) Phase boundary diagram of Gas hydrates (Stability Zone) (modified after Ojha and Sain, 2009).

However, presence of higher molecular weight hydrocarbons or other heavier gases may form structure-II or structure-H with different properties. The natural gas hydrates may occur in different morphological forms such as disseminated, nodular, grain coatings, veins, lenses, layered or massive. Gas hydrates are stable up to few hundred meters below the seafloor, defined as the gas hydrates stability zone (Fig.2b) in the continental margins where the water depth exceeds 500 m. The thickness of the stability zone increases with the increasing water depth, decreasing seafloor temperature and declining geothermal gradient, as can be understood from the phase diagram (Fig.2b). The stability thickness may also be affected by the presence of CO2, H2S and dissolved salts. Since methane is a green-house gas, release of the same to the atmosphere from dissociation of gas hydrates causes global warming. Destabilization of gas hydrates reduces the sediment strength, causing slope failure or geo-marine hazard. Gas hydrates may inhibit normal sedimentation and compaction, and underlying free-gas may lead to excess pore pressure causing drilling hazards.

Gas hydrates are mostly recognized by identifying BSR on seismic section based on its characteristics of (i) mimicking the shape of seafloor, (ii) cutting across dipping strata and (iii) exhibiting large amplitude but opposite polarity event with respect to the seafloor reflection. Presence of gas hydrates reduces the permeability and hence trap 'free-gas' underneath. Thus, the BSR is an interface between the gas hydrates bearing sediments above and free-gas saturated sediments below, and is often associated with the base of gas hydrate stability field.

Gas hydrate "reservoir"

Gas hydrates are unconventional hydrocarbon deposits and much of the work being done world over is in research stage. Therefore an extremely close coordination and work association is requires with leading scientists globally to be updated with the recent developments and device methodologies to incorporate the research to best suit our requirements. Work was carried out on PETREL to identify Bottom Simulating Reflector (BSR) in the seismic section of 3D seismic data of deepwater offshore Mahanadi and to identify presence of sand bodies within gas hydrate stability zone. First the BSR was identified (fig 3) and correlated throughout the block on the basis of three main features like (i) mimicking the shape of seafloor, (ii) cutting across dipping strata; and (iii) having reverse polarity with respect to the seafloor reflection. Along with BSR SEA FLOOR was also correlated and mapped.

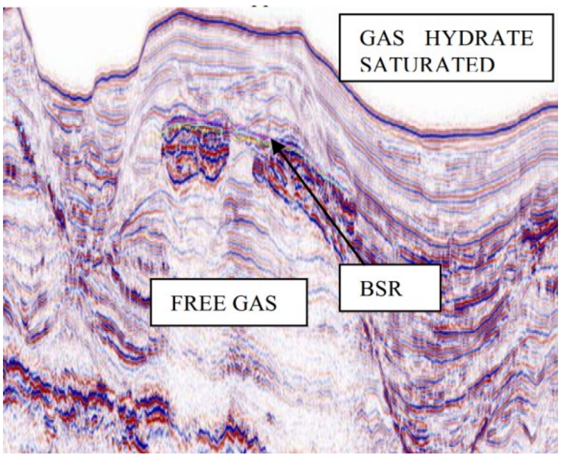


Fig 3 Seismic sections with correlated gas hydrates in Mahanadi offshore

Geologic controls on fluid migration limit the availability of gas and water for the formation of gas hydrate. If migration pathways are not available, it is unlikely that a significant volume of gas hydrate would accumulate. Therefore, geologic parameters such as water and gas chemistry, as well as sediment permeability and the enhancement of flow pathways through sediment deformation (faulting and fracturing) must be evaluated to determine if the required gas and water can be delivered to the sedimentary section potentially hosting gas hydrate. Sand, fractured clay and combination reservoirs are the primary emerging economic targets for gas hydrate production. Because conventional marine exploration and production technologies favor the sand-dominated gas hydrate reservoirs, investigation of sand reservoirs will likely have a higher near-term priority in the NGHP program. It is perceived that the NGHP effort will likely include future drilling, coring, and field production testing. Next we Aim to find the sand location in the Gas Hydrate Stability Zone. For this RMS Amplitude Map (Fig 4 &5) was created to identify the high and low amplitude which will indicate the Sand and Clay location in the survey area

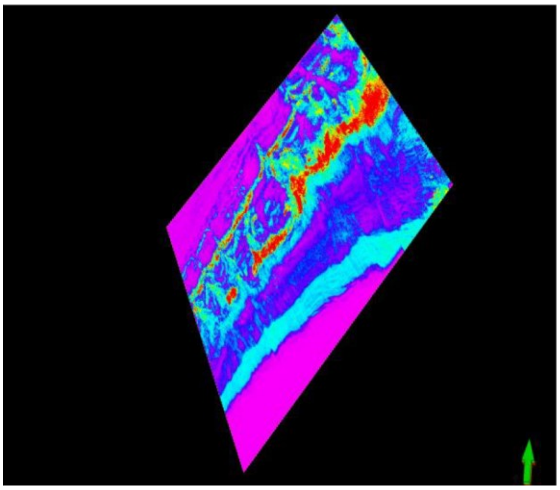


Fig 4 -RMS Amplitude Map 50ms above BSR

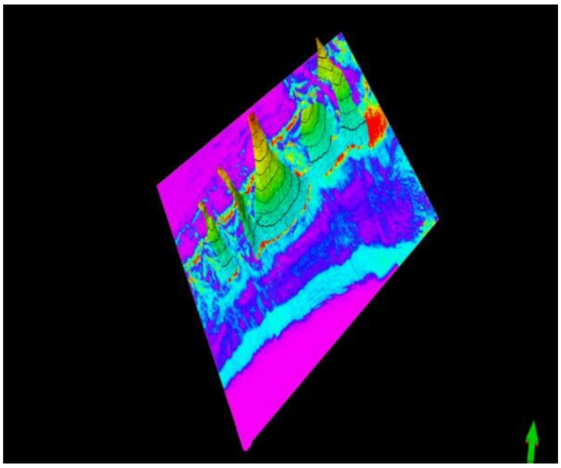


Fig 5 - Rms Amplitude Map with BSR

Observations

We can see both High and low amplitudes in the RMS map and assume that high amplitude is most probability due to sand presence and low amplitude due to clay or shale presence.

If we insert BSR on the RMS map we can see that some portion of the gas hydrate stability zone is present on the sand location.

We can observe some channels that are flowing from elevation from NW to SE directions. Sand are deposited as fan deposit.
A drilling Location can be proposed in these areas where sand and BSR occurs.

Conclusions

The BSR was identified, correlated and mapped and seabed was also correlated to prepare bathymetry map. It was found that BSR is clearly mimicking the seafloor, crosscutting various seismic reflectors and has opposite polarity with respect to Sea bed. In all seismic sections BSR does not seem to follow any geological process, so we may conclude that it is not a geological boundary. Since its depth depends on P-T conditions, it may be called a thermodynamic boundary. The various RMS Amplitude maps were prepared above the BSR and below the seafloor with BSR as reference horizon. On the basis of RMS Amplitude map showing High amplitude patches above and near to the BSR, presence of gas hydrates in sand can be assumed. Several channel features were seen in different time slices and RMS amplitude maps above the BSR in support of presence of sand. The presence of source of sand and its seismic signature confirms the presence of sand bodies above and near to the BSR (Gas Hydrate Stability Zone). Hence, we may locate some points over the sand patches for drilling to explore the gas hydrates in sand bodies.

Exploitation from relatively softer targets of underlying free gas is to be taken up first. Studies in logistically best suited and more favorable Geological setting conducive to gas hydrate formation and areas of high density of gas hydrate occurrence are to be taken up in the initial phases. Efforts for estimating the resources of hydrates for deep offshore areas are to be continued. Research & Development efforts are to be continued to help materialize commercial exploitation of this non-conventional hydrocarbon of vast resources within a few next decades.

As we can see that on the high amplitude region the BSR (fig 6) is present which shows the gas hydrates occupied in sand containing sediments so, it is possible to extract gas Hydrates from these location from where a well can be drilled.

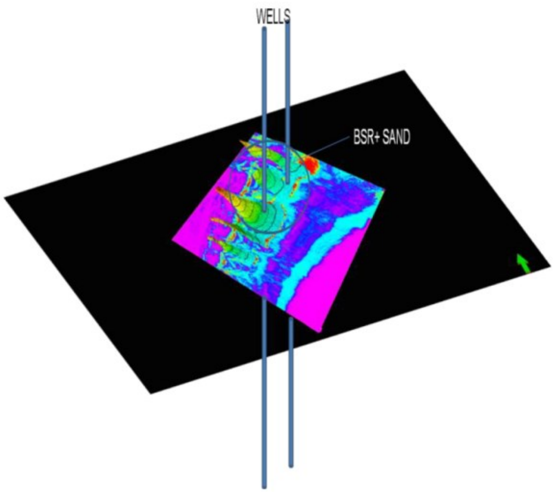


Fig 6 – Model showing drilling locations in sand in Gas Hydrates stability zone.

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