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Distribution of Gas Hydrates indicators in the Magnolia field, Gulf of Mexico

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DISTRIBUTION OF GAS HYDRATE INDICATORS IN THE MAGNOLIA FIELD, GULF OF MEXICO

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ABSTRACT

Gas hydrates are a complex solid structure formed when molecules of light hydrocarbon, usually methane, are trapped in a cagelike structure of frozen water. To be formed, water and gas must exist in an area with high pressure and low temperature in the uppermost few hundred meters in marine sediments or in some permafrost zones onshore. This study investigated the occurrence and distribution of gas hydrate indicators in a reflection seismic dataset from the Magnolia deepwater oil field in the Gulf of Mexico, approximately 180 miles south of Cameron, Louisiana. The first step in this study was to establish the geothermal gradient in the sediments, determine the water bottom temperature, and estimate the gas composition. Common values cited in the literature for this area were used. Subsequently, the program CSMHyd, from the Colorado School of Mines, was used to determine the pressure-temperature stability curve for gas hydrates. The depth range in which hydrates can form, the Gas Hydrate Stability Zone (GHSZ), extends from the seafloor to the depth at which the stability and geothermal gradient curves intersect. The base of the GHSZ horizon was generated throughout the 3D seismic dataset using Petrel Seismic Interpretation software. Strong, reverse-polarity seismic reflections were interpreted to indicate accumulations of free gas trapped beneath the GHSZ, thereby suggesting hydrate presence above the base. The mapped gas indicators are consistent with the presence of gas hydrates as documented in other seismic studies and drilling in other areas within the Gulf. Petrel was used to map faults that might provide conduits for vertical gas migration and that serve to disrupt the continuity of the free gas features. Gas hydrates might be hazardous. Therefore, knowing where they are can prevent potential accidents during drilling operations. Also, gas hydrates may be produced as an energy source someday.

GAS HYDRATE

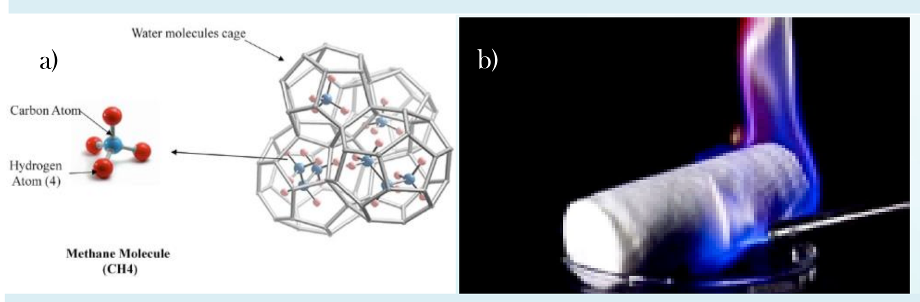


Figure 1 (left): a) Gas hydrate molecule structure (Janda's Group) b) Gas hydrate core sample (courtesy of Geological Survey of Canada)

STUDY AREA

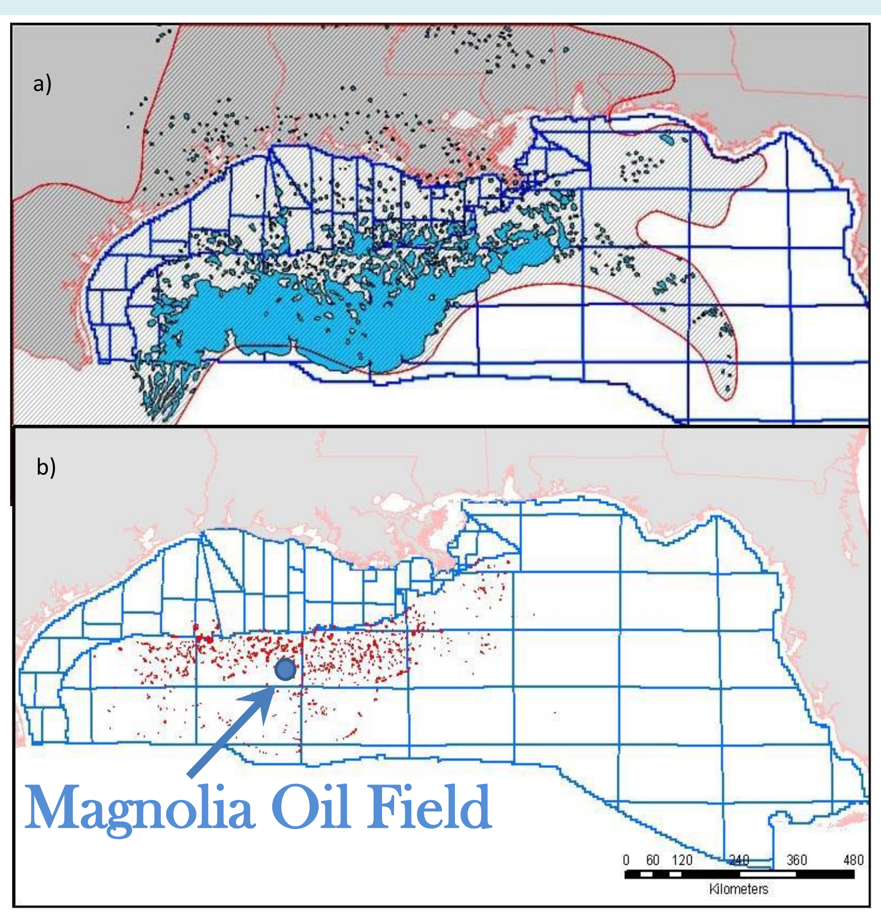


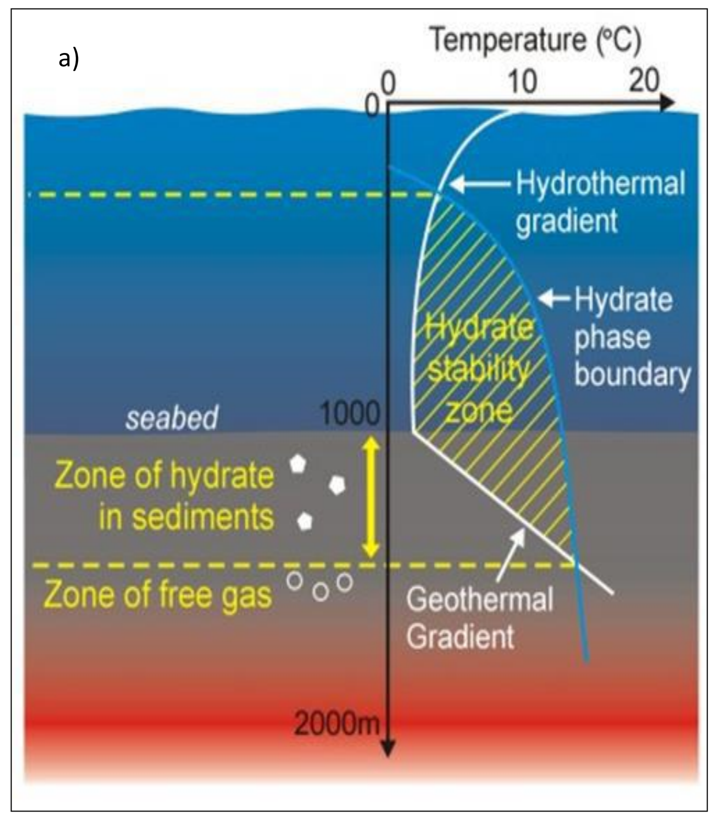
Figure 2 (left): a) Salt distribution in the Gulf of Mexico. The blue area represents the allochthonous (mobilized) salt and the grey area represents autochthonous (in place) salt. b) Gas flux anomalies indicated by the red dots. (Frye, Mattew, 2008)

METHODS

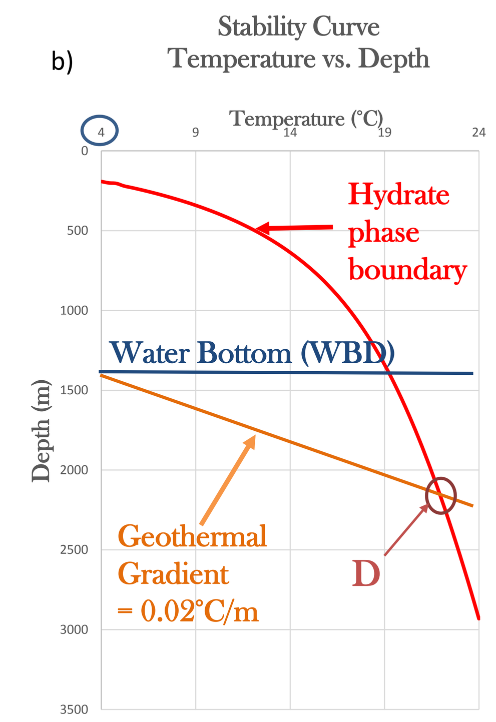
The first step was to define likely values for the geothermal gradient, water bottom temperature, and gas composition for the study area. According to McConnell & Kendall (2003), gas hydrates in the Gulf of Mexico consist of 98% methane, 1% propane and 1% ethane. The water bottom temperature (4°C) and geothermal gradient (20°C/km) were also obtained in the same article. These values were utilized to obtain the pressure at different temperatures within the sediment column using the CSMHyd, a program from the Colorado School of Mines. With the pressure estimated for various temperatures, the equation $P = \rho g h$, where P is the pressure, ρ is the water density, g is the acceleration of gravity, and h the height of the column of sediments was used to calculate the height of the column of sediments. Following, a stability curve for gas hydrates was generated.

WORKFLOW PROCESS

Setting

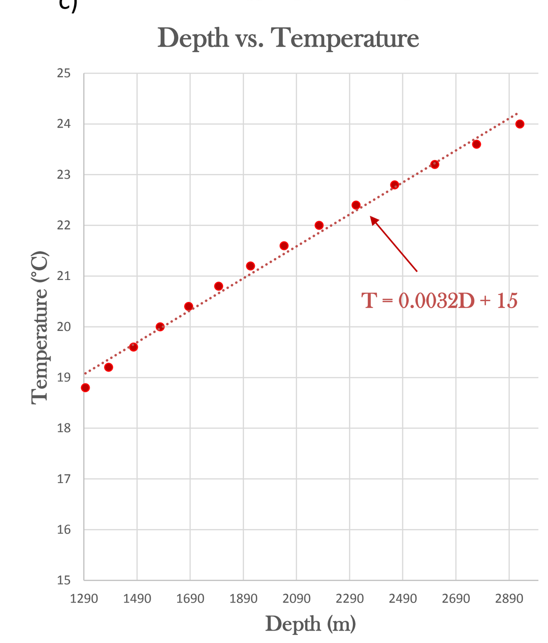


Relationships



$$T = 4 + 0.02(D\text{-}WBD)$$

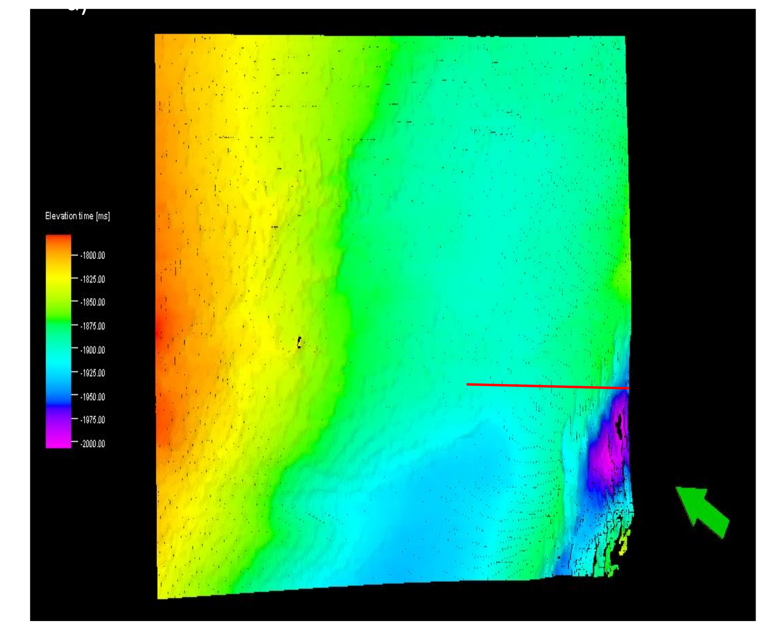
Linearize Phase Curve



$$T = 0.0032D + 15$$

Water bottom surface

d) (geothermal gradient) = T = (linearized stability curve)



$$TWT_{BSGH} = \frac{11 + 0.02\left(\frac{TWT_{WB} x1500}{2}\right)}{0.1685} \frac{2}{1500}$$

Seismic section

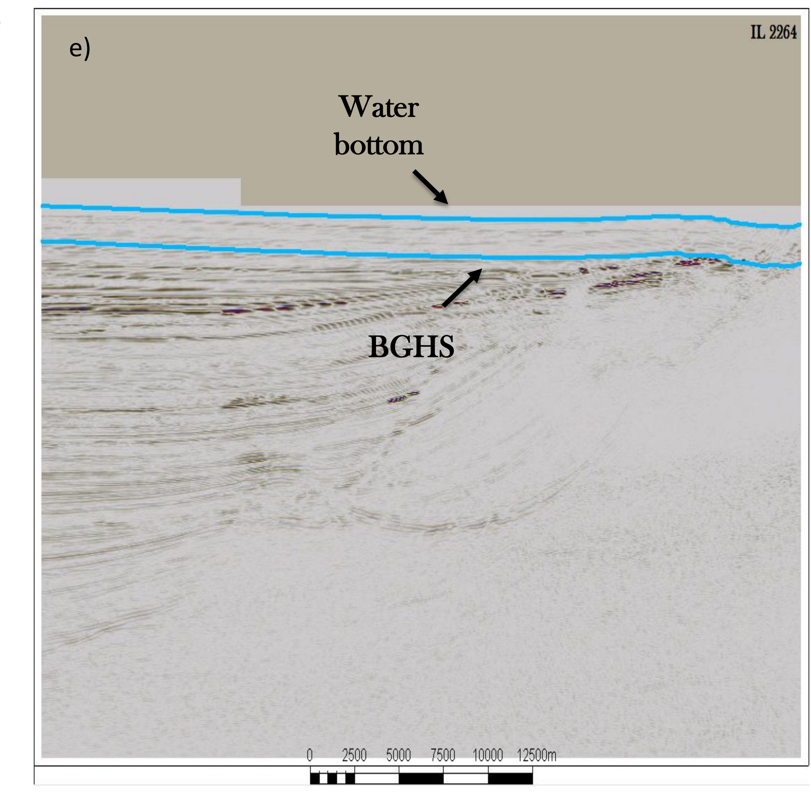


Figure 3: a) Diagram showing how hydrate forms in a zone beneath the seabed defined by the geothermal gradient and the hydrate pressure–temperature stability curve (phase boundary). Free gas and water exist as separate phases below the hydrate stability zone. Retrieved from http://noc.ac.uk March 24. b) Scheme showing the results for the stability in the Magnolia Field and equation describing the geothermal gradient. c) Linear regression based on the interval between the water bottom and the BGHS (Base of the Gas Hydrate Stability) (D in Fig 3. d)). d) Water bottom surface generated in Petrel Seismic Interpretation Software in elevation time and equation used to calculate the BGHS based on the Two Way Travel Time (TWT). The line in red shows the location of the cross section showed in Fig. 5 a). e) Cross section showing the water bottom and BGHS, respectively picked and calculated in Petrel Seismic Interpretation Software.

INTERPRETATION

Interpretation Rules

1) Bottom Simulating Reflection (BSR): Strong reflection with reverse polarity compared, but approximately the same shape as the water bottom.
2) Within the zone of stability, bright spots with the same polarity as the water bottom.
3) Blanking: Reduction of the amplitude of the seismic wave due to a reduction of velocity in the BGHS. Blanking is caused by saturation of open pore spaces by gas hydrates.

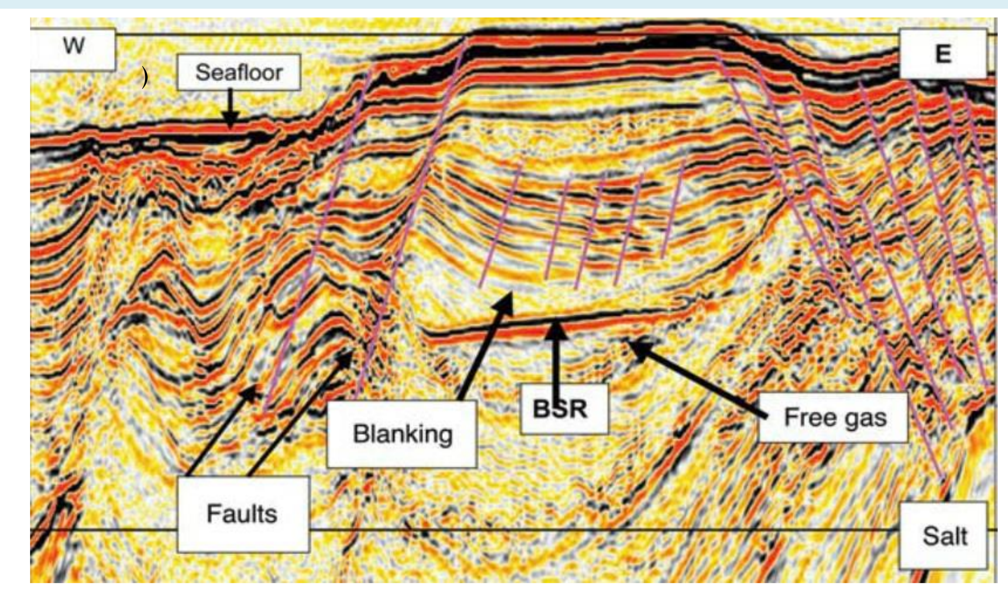


Figure 4 (left): Example of an interpreted seismic section from the literature at Green Canyon, Gulf of Mexico (Kou et al, 2007). Note the BSR is consistent with the presence of gas hydrates as indicated by the high amplitude and inverted color code with relation to the water bottom. Also notice the free gas trapped right beneath the BSR.

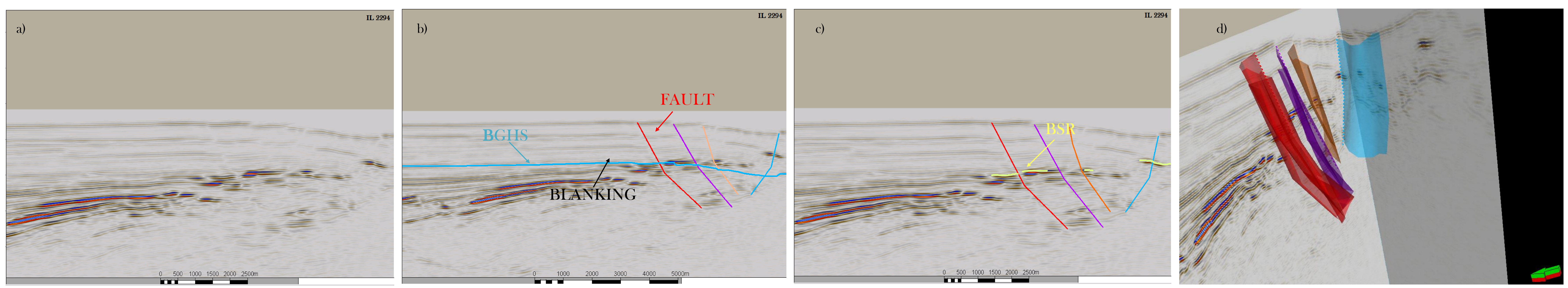


Figure 5: a) Uninterpreted cross-section from Magnolia data set. b) Seismic section containing the faulting interpretation and BGHS c) The BSR in the case of Magnolia does not mimic the water bottom, but is instead displaced due fault movements. Also notice that a portion of the BSR is displaced upward where it overlies the mobilized salt, due the elevated thermal conductivity of the salt. d) 3D distribution of the principal set of faults above the salt diapir. The colored surfaces show the faulting along the volume.

CONCLUSION

1) The presence of gas hydrates in the Magnolia field is corroborate by the existence of BSRs, marked on the seismic data by high amplitudes and reversed polarity. The seismic data set also suggests that the development of a strong BSR is associated with the presence of some free gas beneath the hydrated sediment. The BSR has been modified by the intense faulting and the presence of salt.
2) The gas hydrate and the free gas trapped beneath it may represent a potential geohazard. Problems could arise if the gas hydrate melts during drilling and/or production activities.
3) Although it might represent a risk, according to the United States Geological Survey, the world's gas hydrates may contain more carbon than the world's coal, oil, and other forms of natural gas.

REFERENCES

Kou, William; Smith, Micheal A.; Ahmed, Adnnan and Kuhzela, Roberto, Direct seismic indicators of Gas Hydrates in Walker Ridge and Green Canyon areas, deepwater Gulf of Mexico: *The Leading Edge.* 2007

Frye, Matthew. Preliminary Evaluation of In-Place Gas Hydrate Resources: Gulf of Mexico Outer Continental Shelf: *U.S. Department of the Interior Minerals Management Service Resource Evaluation Division.* 2008

McConnell, Daniel R.; Kendall, Beth A. Images of the base of gas hydrate stability in the deepwater Gulf of Mexico: Examples of gas hydrate traps in northwest Walker Ridge and implications for successful well planning. *The Leading Edge.* 2003

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