Comparing Mud Volcano Characteristics and Association with Oil and Gas

Senior Thesis
Submitted in partial fulfilment of the requirements for the
Bachelor of Science Degree
at
The Ohio State University

By

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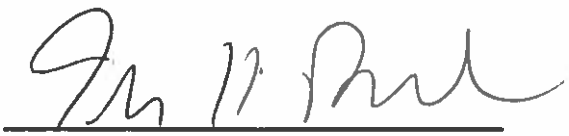
The Ohio State University
2018

Approved by



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Abstract

Looking the variability of mud volcanoes and its association with oil and gas throughout the world and how some mud volcanoes more unique compare to others. By comparing several mud volcanoes in different continents and looking through their geologic structure history several different cases are found on some mud volcanoes. The presence of mud volcanoes in Azerbaijan affects the flow of mud and fluid, causes the surrounding water to have higher concentration of metal ions compared to sea water and water expelled from other mud volcanoes worldwide. The presence of mud volcanoes in Yinggehai Basin and South Taiwan Basin to have a different type of hydrocarbon gas and isotopes values. Lastly the distribution of sub mud volcanoes worldwide with different geologic history that resulting in variation of hydrocarbon content.

Acknowledgments

I would like to thank Thomas H. Darrah, my thesis advisor who provide guidance and data that I needed to complete my thesis. Librarian specialist Danny Dotson helped me gathere and provide access to the material I needed for my thesis. Anne Carey provided guidance on how to make a successful thesis. Many previous professors from my previous classes helped me build up my foundation critically to complete this work.

Special thanks to my parents that always supporting and encouraging me pursuing my degree. Who also worked hard to provide financial stability for me to achieve my dreams. Words could not describe how thankful I am for their support and hard work.

Introduction

The first overall objective of this study is to compare characteristic of mud volcanoes around the world. What is the relation and association of mud volcano with oil and gas? I found it very curious why different mud volcanoes have different association with oil and gas. The second objective is to determine if mud volcanoes can be a good indicator for oil and gas. There are a lot of good oil and gas indicator such as salt domes, faulting or folding. The third objective is to find the effect or impact of mud volcano to its surrounding environment.

Methods

Seismic Waves

The use of Seismic waves or Lines provides an option for us to identify the geologic formation or history on subsurface basis. In this case Seismic is used to identify mud volcanoes and any hydrocarbon potential (oil and gas). Observation of seismic lines from different Mud volcanoes in different location and comparing the result provides an answer on how Mud volcanoes in various location would have a different or similar association with oil and gas.

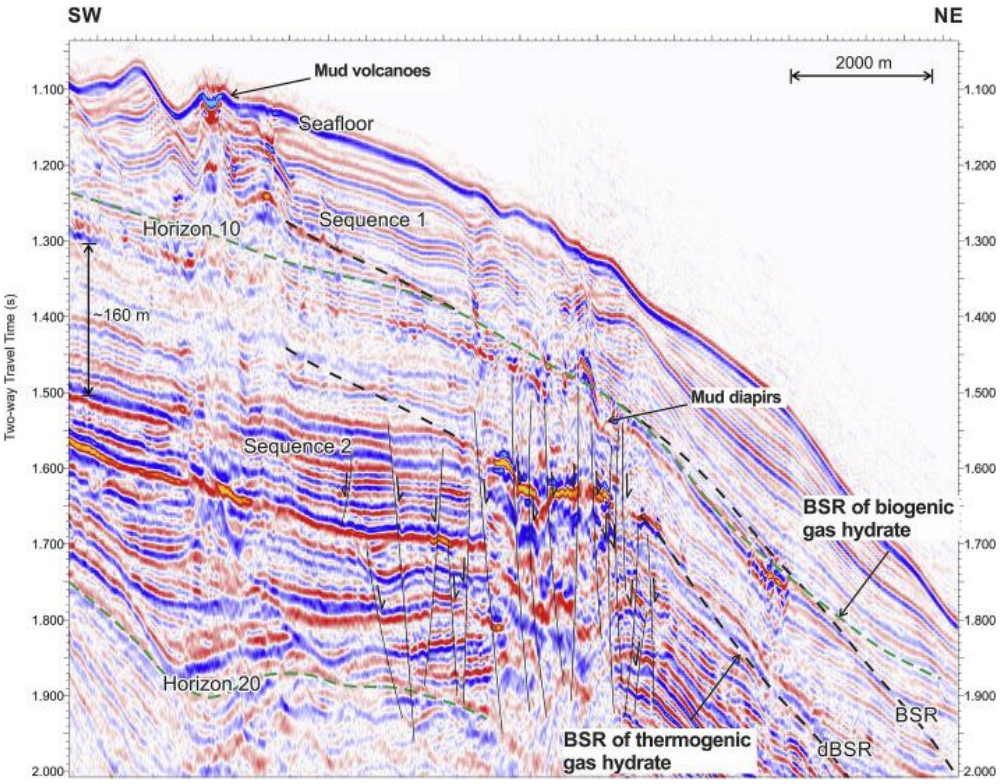

Fig 1. Seismic line interpretations on subsurface basis, Kutai basin East Kalimantan (Wright and Zhang, 2017).

Well Logging

A seismic line provide a location of subsurface hydrocarbon. However, it does not necessarily reveal the type of hydrocarbon. Well log data provide more detailed information on the type of hydrocarbon potential in a subsurface basis. With Gamma Ray, Neutron, and Resistivity sources, we can determine the type of hydrocarbon present on that current formation. In this case well log data are used to determine the type of hydrocarbon located with mud volcanoes in various location and determinehow differ or similar is the hydrocarbon content in different location.

Sample using stable isotopes

To further analyze the characteristic of mud volcano their relationship with oil and gas, samples from hydrocarbon onsite can be taken and analyzed using stable isotopes and helium (He). Using the hydrocarbon composition along with its carbon and He isotopes we can determine the comprehensive analysis of geological conditions of its source rock.

Results

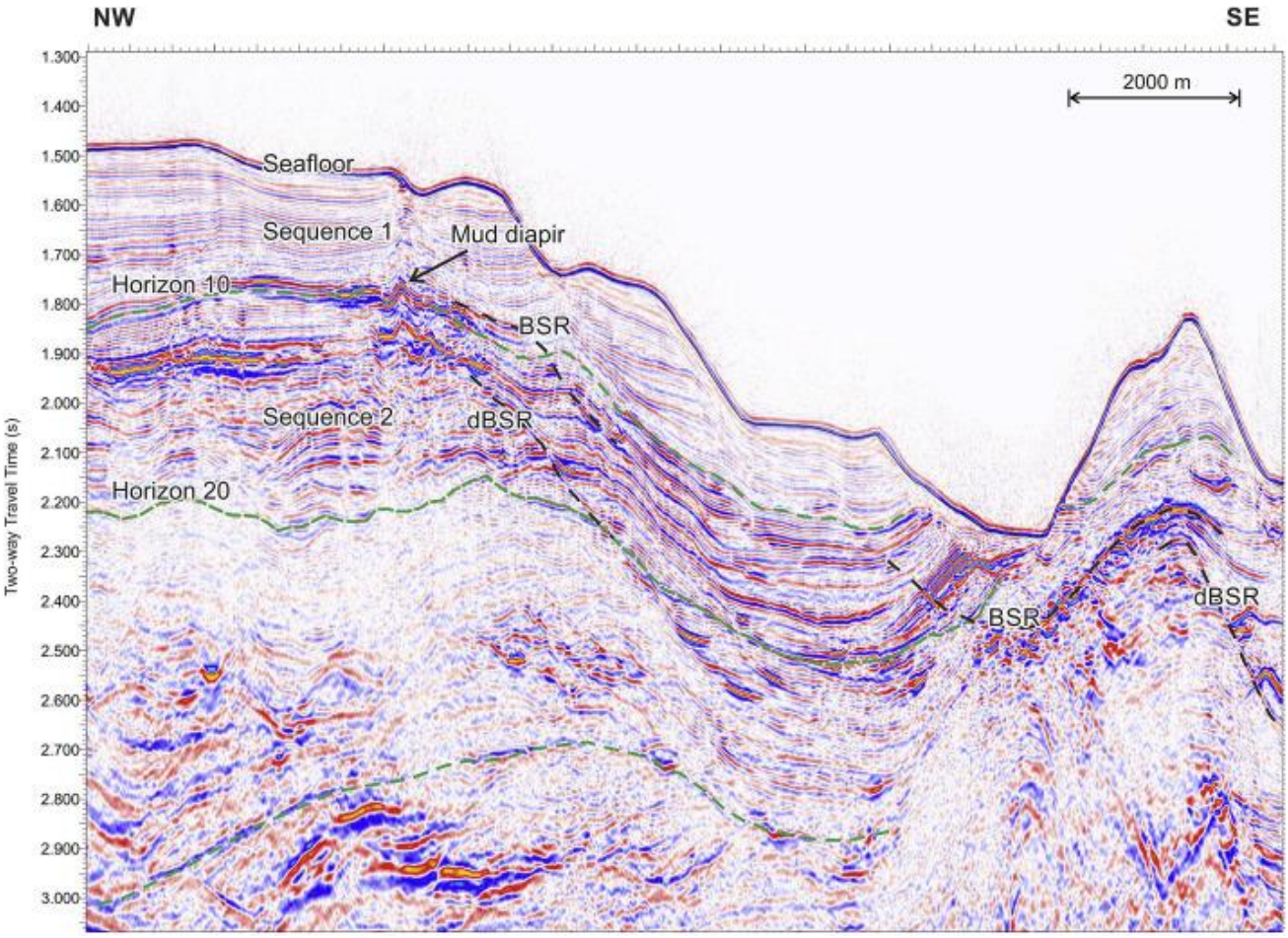

Figure 2. Interpreted regional seismic line with two locations of BSR and a mud diapir as an example of the association of hydrocarbon with mud volcano. Geologic setting confirmed the present of fault around the first and second BSR. (Wright and Zhang 2017)

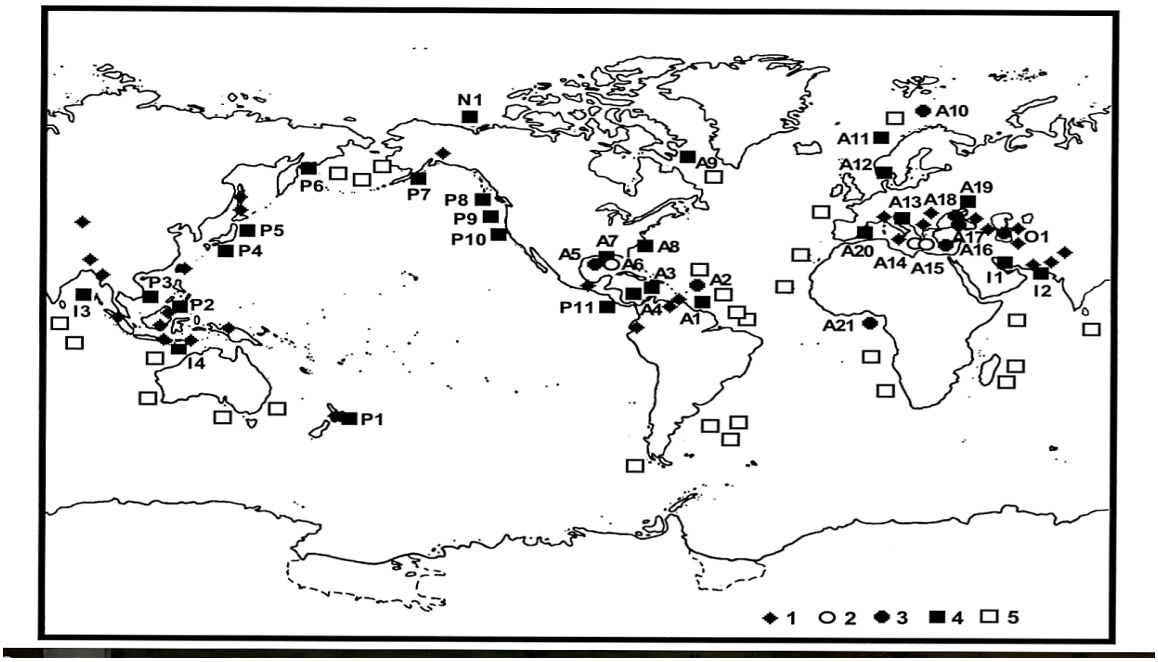

Table 1
Summary of known submarine mud volcanoes

Reference to Fig. 1	Region	References
A2	Offshore Barbados Island	Biju-Duval et al. (1982); Stride et al. (1982); Brown and Westbrook (1988); Langseth et al. (1988); Le Pichon et al. (1990); Henry et al. (1990; 1996); Lance et al. (1998)
A6	Gulf of Mexico, upper continental slope	Neurauter and Bryant (1989; 1990); Sassen et al. (1993); Neurauter and Roberts (1994); Aharon (1994); Kohl and Roberts (1994); Corthay (1998)
A7	Gulf of Mexico, lower continental slope	Prior et al. (1989)
À10	Norwegian Sea	Vogt et al. (1997, 1999); Ginsburg et al. (1999); Milkov et al. (1999); Bogdanov et al. (1999)
A14	Offshore Greece (Mediterranenan Sea, Prometheus area)	Cita et al. (1981)
A15	Offshore Crete (Mediterranenan Sea, Pan di Zucchero, Prometheus-2, Olimpi and United Nation Rise areas)	Camerlenghi et al. (1992, 1995); Limonov et al. (1994); Ivanov et al. (1996); Cronin et al. (1997)
A16	Offshore Cyprus (Mediterranenan Sea, Anaximander Mountains region)	Woodside et al. (1997)
A17	Black Sea, deep-water part	Konyukhov et al. (1990); Ivanov et al. (1992); Limonov et al. (1994)
A18	Black Sea, Sorokin Trough	Woodside et al. (1997)
A21	Offshore Nigeria	Heggland et al. (1996); Heggland and Nygaard (1998)
O1	Caspian Sea	Yakubov et al. (1971); Ginsburg and Soloviev (1994)

Figure 3. The table distribution of submarine volcanoes around the world. The distribution of submarine volcanoes is following two criteria identifications. (1) the presence of mud volcanic sediment cores, (2) the present of local topographic features distinguished specific relief and strong backscatter. The blackened square from the figure above are the location in which the submarine volcanoes located. (Milkov, 1999)

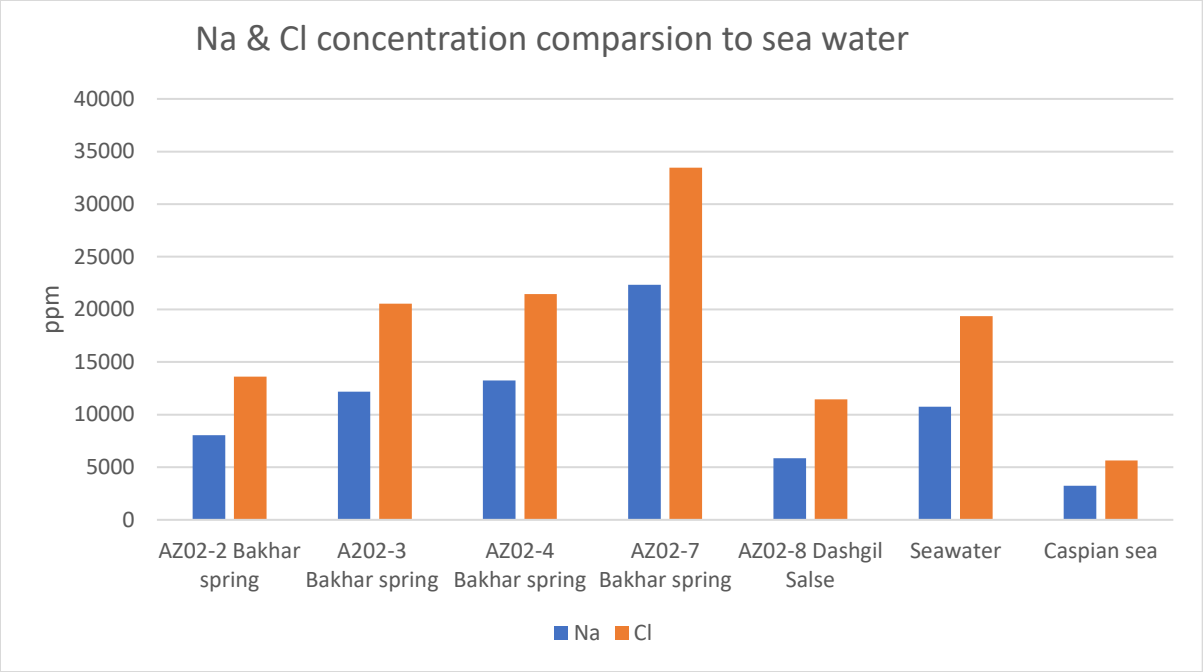

Figure 4. Composition of water seeps sample that taken from several different mud volcanoes location within Bakhar and Dashgil, Azerbaijan. The water seeps composition dominated by Na and Cl ions, with Cl content ranging from 11,000 to 33,000 ppm. The presence of mud volcano enriched the sodium and chloride content of water surrounding it. the water is this region are richer in B ions and metal content compared to sea water and other water expelled from mud volcano worldwide (Banks et al,. 2003.)

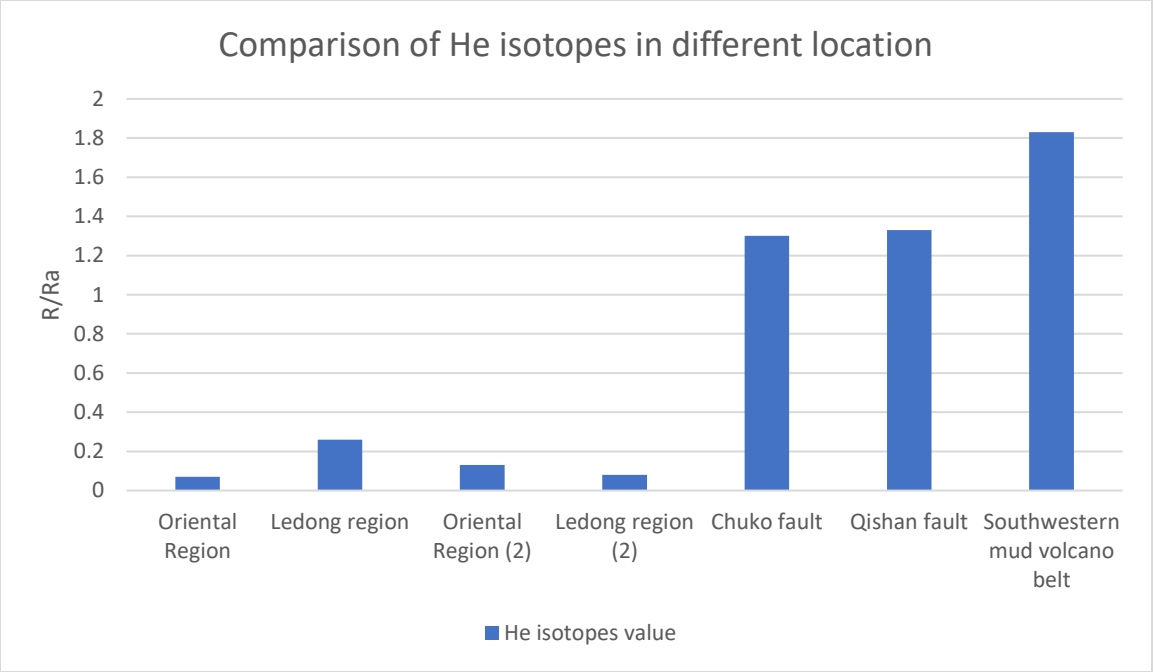

Figure 5. Isotopes value sample taken at Yinggehai Basin and Southwest Taiwan Basin, Taiwan. The huge different in value is caused by the present of mud volcanoes at the sample locations.

Discussion

Geologic Setting

The distribution of mud volcano varies throughout the world. It depends on the geologic environment on subsurface basin whether it is onshore or offshore. However, there are some basic characteristics for mud volcanoes to develop. Mud volcanoes are commonly showed with lines of fracture, faulting or folding. The distribution of submarine volcanoes are made following two criteria identifications. (1) the presence of mud volcanic sediment cores, (2) the present of local topographic features distinguishing specific relief and strong backscatter (Milkov, 1999) which is very similar to how onshore mud volcano is form that usually related to seismic volcano activities. What is the cause of variability of mud volcano? Why is not every mud volcanoes are associated with oil and gas? Some mud volcanoes have more fluid ions concentration than the other or different types of hydrocarbon gases. Use of seismic wave will give us the subsurface geologic features and reason to variability of mud volcano.

Association with oil and gas

Mud volcanoes are essential to oil and gas industry since mud volcanoes are originated by suppressed hydrocarbon gases mixed with fluid and sediment. Mud volcanoes may provide evidence of high petroleum potential in deep subsurface, gas hydrate associated with mud volcanoes are high potential energy (Milkov, 1999) That being said there are only small numbers of mud volcanoes that are associated with petroleum. There is a range of temperature of oil window in which would heat and cook organic material to oil. It cannot be too warm or too hot. Since mud volcanoes are associated with volcanic activity the temperature surrounding it would be too high for oil catagenesis but good enough for gas catagenesis. However, there are some cases where mature oil is found within the area of mud volcano. This may be caused by local geologic setting such as faulting, fracture, or folding or even triggered by natural seismic activities like earthquake.

Fluid ion concentration

Mud volcanoes are associated with hydrocarbon and are rich in minerals. Upon eruption that normally last for less than few hours, and characterized with vigorous mud breccias, hydrocarbon gases and water (Banks et al., 2003) The excess water can be sampled and compared with other mud volcanoes worldwide. Most commonly each mud volcano will have similar ion concentrations. However, this is not the case with mud volcano at Azerbaijan. Samples were taken from several locations in Bakhar and Dashgil. The presence of mud volcano enriched the content of water surrounds it. The waters is this region are richer in B ions and metal content compared to sea water and other water expelled from mud volcano worldwide (Banks et al. 2003) This is caused by mixing of deep and shallow waters in the presence of intermediate-depth mud chambers. The expelled water affected by chemival processes such as mineral dehydration, redox reaction, or degradation of organic material.

Gas composition

There are many variations in the types of hydrocarbon gases that are associated with mud volcanoes, with one of the most common being methane. Using stable isotopes samples from the Southwest Taiwan Basin mud volcanoes we can identify two different type of gas. The associated gases are carbon dioxide, non-hydrocarbon gas, and methane-rich hydrocarbon gas. The two gases are formed with the help of mud diapir, that results in high temperature and pressure suited for methane gas to form. The mud diapir also provides a driving force for oil and gas migration and accumulation (He, et al. 2016) the hydrocarbon gases itself can be further classified to biogenesis or sub-biogenesis and mature oil type or mature coal type.

Conclusion

The variability of mud volcanoes and their association with oil and gas are mostly caused by geologic formation. Not every mud volcano would have a mature economic oil since the area surrounding it would have a higher oil range temperature. However, every mud volcano would have mature hydrocarbon gases. This leads to the conclusion that mud volcanoes can be an indicator for hydrocarbon gases such as methane. The present of mud volcanoes also can affect its surrounding area, such as higher Na and Cl concentration within expelled water compared to other sea water around the world. In addition, it also increases the amount of He ions found from sample that can contribute to a different type of source rocks.

Recommendation for Future Work

Mud volcanoes are very common and it can be found on land or sea floor and are not solely related to oil and gas. There is more alternative energy that can be associated with mud volcano such as geothermal. The study of mud volcanoes is very broad and sometimes it is economically desired. Focusing on ions and elements investigation found within mud volcanoes and how mud volcanoes affect the localize area might be a good start for understanding the economical value of mud volcano.

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