

GAS HYDRATE ACCUMULATION ASSOCIATED WITH MARINE MUD VOLCANO

E.I. Suetnova

Schmidt Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia

Abstract. The presented mathematical model is developed as a theoretical basis of the mechanism of gas hydrate accumulation in vicinity of marine mud volcano. The model accounts for gas hydrate forming in the PT stability zone due to filtration of gas saturated pore fluid in the vicinity of mud volcano above high pressure mud source layer. The model calculations show that hydrate accumulation rate depends on hydrodynamic properties of sediments above mud source layer, their porosity, thermal gradient, and physical properties. Also hydrate accumulation rate depends on the depth of the source layer and the pressure inside it. It is shown that a time to reach the steady state filtration depends on the same parameters.

In frames of the model, the influence of permeability and mud source depth on the accumulation rate was analyzed. The calculations show that the maximum rate of gas hydrate accumulation is 2.6 % of the porous space during 100 years with permeability equal to $k=10^{-14}$ m², temperature gradient 0.05° Km⁻¹, mud source depth 1000 m, and sea depth 1200 m. Such a high hydrate accumulation rate during centuries can provide significant gas hydrate saturation in vicinity of mud volcano, which is consistent with experimental data.

The process of gas hydrate accumulation associated with mud volcanoes is qualitatively characterized. The dependence of maximum rate of accumulation on the filtration characteristics of sediments and geophysical parameters of medium is obtained. It can be applied to model the gas hydrate saturation in vicinity of mud volcanoes during a time period between eruptions.

Keywords: gas hydrate, mud volcano, mathematical and numerical modeling

References

- Basniev A. T., Kochina I.N., and Maximov V.M., *Podzemnaya gidromekhanika* (Hydromechanics of underground), Moscow: Nedra, 1993.
- Carslow H.S. and Jager J.C. *Teploprovodnost tverdih tel*, Moscow: Nauka, 1964.
- V. N. Nikolaevskii, K. S. Basniev, A. T. Gorbunov, and G. A. Zotov, *Saturation Mechanics of Porous Media*, Moscow: Nedra, 1970. 338p.
- Charnyi V.A., *Podztnnaya gidrogazodinamika*, Moscow: Gostekhizdat, 1963.
- Davie M.K. and Buffett B.A., A numerical model for the formation of gas hydrate below the seafloor, *J. Geophys. Res.*, 2001, v. 106, no B1, pp. 497–514.
- Davie M.K., Zatsepina O.Ye., and Buffet B.A., Methane solubility in marine hydrate environments, *Marine Geology*, 2004, vol. 203, pp.177–184.
- Egorov A.V., Crane K., Vogt P.R., and Rozhkov A.N. Gas hydrates that outcrop on the sea floor: stability models, *Geo-Marine Letters*, 1999, vol. 18, pp.68–75.
- Haacke R.R, Westbrook G.K., and Hyndman R.D., Gas hydrate, fluid flow and free gas: Formation of the bottom-simulating reflector, *Earth and Planetary Science Letters*, 2007, vol. 261, pp .407–420.

- G. D. Ginsburg and V. A. Solov'ev, *Submarine Gas Hydrates*, VNIIOkeangeologiya, 1994.
- Ginsburg G.D., Milkov A.V., Soloviev V.A., Egorov A.V., Cherkashev G.A., Vogt P.R., Crane K., Lorenson T.D., and Khutorskoy M.D., Gas hydrate accumulation at the Haakon Mosby Mud Volcano, *Geo-Marine Letters*, 1999, vol. 19, pp. 57–67.
- Golmshtok, A.Y., The impact of faulting on the stability conditions of gas hydrates in Lake Baikal sediments. *Izv., Phys. Solid Earth*, 2014, vol.50, no. 4, pp. 528–542.
- Kholodov V.N., Gryazevie vulkani: zakonomernosty ikh razmescheniya i genesis. *Litologiya i poleznie iskopaemiy*. 2012. no 3. pp. 227–241.
- Mazzini A., Mud volcanism: Processes and implications, *Marine and Petroleum Geology*, 2009, vol.26, pp.1677–1680.
- Mazurenko V., Soloviev A., [Belenkaya I.](#), Ivanov, M. K., and Pinheiro, L. M., Mud volcano gas hydrates in the Gulf of Cadiz, *Terra Nova*, 2002, vol.14, no. 5, pp.321–329.
- Nimblett J. and Ruppel C., Permeability evolution during the formation of gas hydrates in marine sediments, *J. Geophys. Res.*, 2003, vol. 108, no B9, EPM 2-1, Cite ID 2420, DOI 10.1029/2001JB001650.
- Perez-Garcia C., T. Feseker, J. Mienert, and C. Berndt, The Håkon Mosby mud volcano: 330 000 years of focused fluid flow activity at the SW Barents Sea slope, *Marine Geology*, 2009, vol. 262. pp. 105–115.
- Rempel A.W. and Buffett D.A. Formation and accumulation of gas hydrate in porous media, *J. Geophys. Res.*, 1997, vol. 102, no B5, pp. 10151–10164.
- Sloan E.D., *Clathrate Hydrates of Natural Gases*, N.Y.: Marcel Dekker, 1998. 705 p.
- Suetnova E. I., Accumulation of Gas Hydrates and Compaction of Accumulating Sediments: The Interaction Problem, *Dokl. Akad. Nauk*, 2007, vol. **415**(6). pp. 818–822.
- Suetnova, E.I., Influence of the sedimentation regime and compaction of sediments under subaqueous conditions on the accumulation of gas hydrates in the zone of their stability. *Izv., Phys. Solid Earth*, 2008, vol. 44, no.9. pp. 748–753.
- Suetnova E.I., Osobennosti akumulatsii gasovikh gidratov pri razlichnykh urovnyakh fluidnogo davleniya, formirovaniya v osadkach pri ikh nakoplenii, (Peculiarity of gas hydrate accumulation due to the different fluid pressure which are forming during accumulation of sediments), *Geophys. Res.*, 2009, vol. 10, no 2, pp. 69–76.
- Suetnova E.I., Accumulation of gas hydrates at the bottom of the sea during sequential deposits of sediments with different transport properties, *Doklady Earth Sciences*, 2011, vol. 438, no.2, pp. 883–886.
- Tinivella U. and Giustiniani M. An Overview of Mud Volcanoes Associated to Gas Hydrate System. <http://dx.doi.org/10.5772/51270>. 2007.
- Zatsepina O.Ye. and Buffett B.A. Phase equilibrium of gas hydrate: implication for the formation of hydrate in the deep sea floor, *Geophys. Res. Lett.*, 1997, vol. 24, no 13, pp.1567–1570.
- Zatsepina O.Ye. and Buffett B.A., Thermodynamic conditions for the stability of gas hydrate in seafloor, *J. Geophys. Res.*, 1998, vol. 103, no B10, pp. 24127–24139.