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南海北部神狐海域天然气水合物形成聚集的数值模拟研究

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Numerical modeling of gas hydrate accumulation in the marine sediments of Shenhu Area,Northern South China Sea

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摘要 利用2D数值方法对南海北部陆坡神狐海域水合物形成聚集过程进行了模拟, 对气烟囱、泥底辟与水合物成藏间的关系进行研究. 模拟结果表明, 来自深部的甲烷热解气在向上运移过程中以垂向运动为主, 且局限在某一狭窄的范围内, 故在地震剖面上显示为气烟囱及顶部BSR.只有当其越过水合物稳定带底界, 才能形成水合物, 此时BSR等于水合物稳定带底界. 而一旦水合物形成, 该地层即成为封堵层, 从而阻止甲烷继续向上运移. 因此, 水合物仅仅在水合物稳定带底界上方很薄的一层, 饱和度却可以很高. 此后如果深部气源停止供气, 那么气烟囱会逐渐消失, 只留下水合物存在. 因此, 气烟囱的存在并不一定对应着水合物存在. 另外, 模拟结果还显示, 断裂流体活动(泥底辟)对水合物形成并不十分有利.来自深部的甲烷流量与流体流量之间的匹配很重要, 在甲烷流量一定的情况下, 流体流量越大, 越不容易形成水合物.

关键词: 天然气水合物 数值模拟 神狐海域 气烟囱

Abstract: Shenhu is located in the middle of northern South China Sea. The bottom simulating reflector (BSR) exists widely in the area, and the strong BSR appears mostly in the diapiric structure or at the top of gas chimney. Drilling showed that gas hydrate was only distributed in the upper 10~25 m range above the bottom of hydrate stability zone (BHSZ), but with the maximum saturation of up to 48%. We designed a 2D numerical model to simulate the formation and accumulation in the marine sediments, aiming to understand this unique feature of gas hydrate, as well as to study the relationship between gas chimneys, mud diapirism and gas hydrate reservoir. Modeling results indicate that the methane from deep moves upward vertically and is confined to a rather narrow range, which is shown as gas chimney in the seismic section and BSR at its top. During the process of slow movement of gas, the BSR (top of gas chimney) is always lower than the BHSZ controlled by temperature and pressure. Unless it crosses the BHSZ hydrate cannot form. In case the hydrate forms, the stratum becomes a sealing layer, thereby preventing the continued migration of methane. Consequently, the hydrate only forms within a very thin layer above the BHSZ, but the saturation can be very high. After that, if the gas supply from deep stops, the gas chimney will gradually disappear, leaving only the hydrate. So, the existence of gas chimney does not necessarily correspond to hydrate. In addition, the modeling results also show that the fracture fluid activity (diapir) is not always favorable to the hydrate formation. If the fluid flow from deep is very large, all the methane may dissolve in fluid once produced, and is taken away. Thus, no free gas and hydrate is able to form. Only when the methane flow matches the fluid flow can the hydrate form. Therefore, the larger the fluid flow, the more difficult to form hydrate.

Keywords: Gas hydrate Numerical modeling Shenhu area Gas chimney

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