14.20: Low temperature and high pressure deepen the hydrate stability zone in rapidly formed basins

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ABSTRACT

We explore the mechanisms driving overpressure and low temperature in rapidly formed sedimentary basins. We show that under rapid sedimentation, the thickness of the gas hydrate stability zone (GHSZ) can at least double relative to its equilibrium depth due to both low temperatures and elevated pressures. During rapid sedimentation (>0.5 mm yr^{-1}), cold sediment is rapidly buried and there is not sufficient heat flow to keep the sediment at its steady state temperature. In addition, rapid deposition marine mud results in overpressure due to the inability of the pore fluid to drain. The combined effect is that the sedimentary basin is colder and has higher pressure relative to its equilibrium steady state (Figure 1). We further use seismic, well data, and salt restoration to simulate the two-dimensional evolution of pressure, temperature and GHSZ in the Terrebonne Basin, Gulf of Mexico. In the basin center, rapid burial reduces the geothermal gradient from ~30°C/km, which would be expected under equilibrium pressure and temperature, to as low as ~10 °C/km; we also show that an overpressure up to 25 Mpa is developed. The GHSZ thickens towards the basin center, where it reaches ~2000 meters, which is ~3 times deeper than under the equilibrium conditions (Figure 2). A bottom simulating reflection also deepens basin-ward in striking agreement with the increasing sedimentation rates. In the Terrebonne and similar rapidly formed basins, an expanded cooled zone

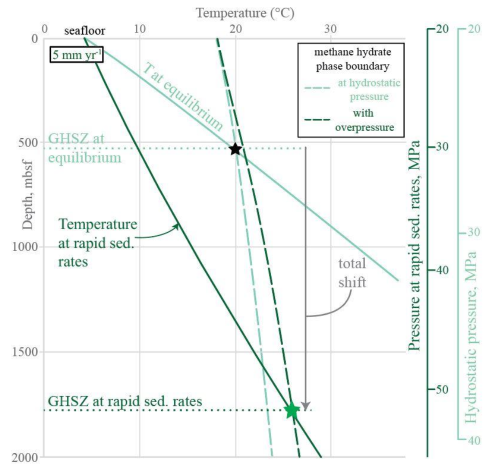


Figure 1: Phase diagram showing methane hydrate phase boundary (dark green dashed line), and pressure-temperature path for the mud deposition simulations at 5 mm yr^{-1} (dark green), 0.5 mm yr^{-1} (light green) sedimentation rates, and at equilibrium (aquamarine curve). Rapid deposition of mud results in a pressure-temperature path that intersects the phase boundary at a much higher pressure and higher temperature than for the equilibrium case.

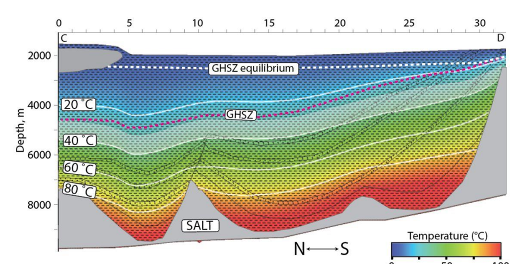
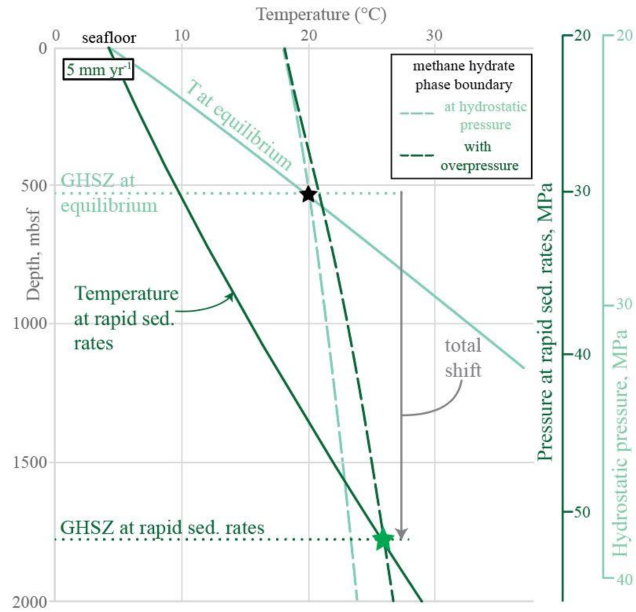


Figure 2: Present day temperature distribution in the Terrebonne Basin. Similar to the overpressure, modern sediment temperature shows extremely low values in the area with high sedimentation in the central and northern Terrebonne Basin. Both, pressure and temperature anomalies driven by rapid sedimentation result in extremely deep base of

deepens and widens the thermal window for microbial methane production; in addition, microbial methane can be hydrate-trapped within a significantly wider depth interval. **CLICK ON IMAGE FOR LARGER VIEW**	GHSZ (red dashed line). Semi-transparent white band under the GHSZ indicates potential pulse in microbial methanogenesis occurring within 30-40 °C temperature window.



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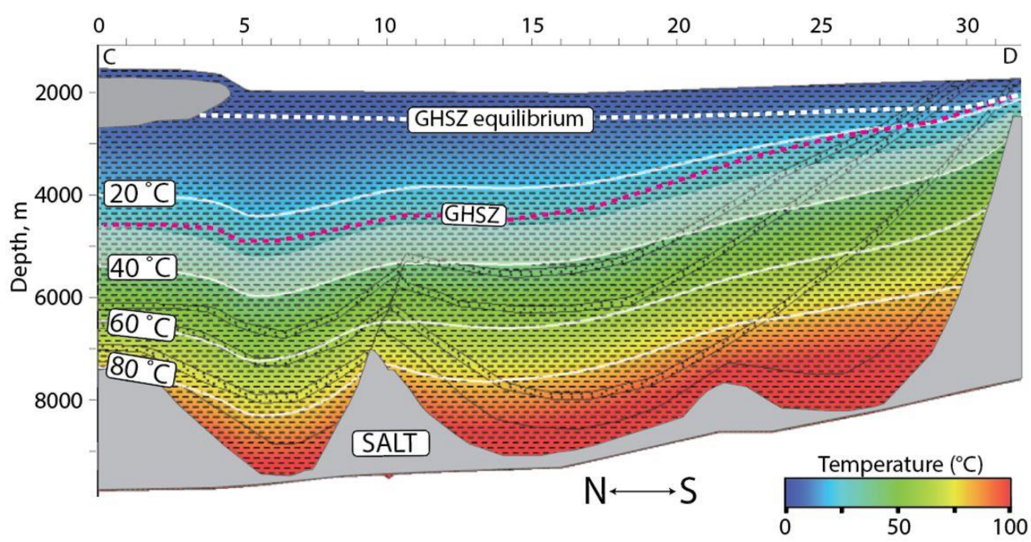

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