# Origin and evolution of $H_2S$-bearing methane hydrate in the Sea of Japan

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Thick massive deposits of hydrates of the Sea of Japan have accumulate in gas chimneys in two steps. The first step is related to a 25 million years' rifting of the Sea of Japan, characterized by a high heat flows, high TOC sediments and a tectonic inversion at a few million years ago. Tectonic inversion has developed deep reverse faults and tight folds with open fracture systems, which facilitated the development of gas chimney structures. Second one is a glacial-interglacial cycles for a few 100 ka. Eustatic sea level fall resulted in a shoal up the base of gas hydrate stability (BGGS), dissociation of deep-seated hydrates, and enhanced methane-flux and massive accumulation of hydrates. Shallow hydrates are characterized by high H2S contents up to a few %v/v, reflecting AOM in shallow subsurface. Shallow H2S-bearing hydrates have repeatedly and intermittently accumulated on the top of gas chimneys at glacial period, while the H2S contents rapidly decreased with depth due to recrystallization perhaps through molecular diffusion during burial diagenesis. Key conditions to develop massive deposits of shallow hydrates are strong flux of mixed-microbial and thermogenic gases and a recycling of deep-seated hydrates during the glacial-interglacial.

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