

Processes involved in massive gas hydrate formation in the Sea of Japan as inferred from U-Th ages of MDAC and from H₂S concentrations of hydrates

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More than a decade of gas hydrate exploration in the Sea of Japan has revealed that the hydrates occur as thick massive deposits in hemi-pelagic mud corresponding to seismic data of columnar blanking zones called “gas chimneys”. The volume fraction of hydrates in these gas chimneys has been estimated to be 35 to 86 vol.% [1]. LWD has revealed extreme depth-profile anomalies including very low natural gamma ray values (<10 API) and high acoustic velocities (2.5 to 3.5 km/s) extending across 30 to 50 m-thick intervals down to the base of gas hydrate stability (BGHS) at 120mbsf [1]. Both pressure and non-pressure coring have recovered thick massive hydrates, often associated with methane-derived authigenic carbonates (MDACs), likely an indicator that the enhanced methane flux both accelerated the formation of hydrates and resulted in an alkalinity-increase at the sulfate methane transition (SMT) that caused MDAC precipitation. U-Th ages of MDACs taken from the shallow subsurface range in age from zero to 40ka, centered around the LGM, suggesting that the methane flux was enhanced due to eustatic sea-level fall and subsequent dissociation of deep-seated hydrates right above the BGHS. The ages of MDACs at depth are also nearly identical to the host sediments, indicating that the MDACs were formed contemporaneously and perhaps indicating that the hydrates were also formed at the shallow subsurface. Hydrates in the shallow subsurface (< 20mbsf) are characterized by high H₂S concentrations corresponding to sulfate reduction at SMT; however, deep-seated hydrates are observed to be low or substantially free of H₂S. The depth profile of hydrate-bound H₂S and age of hydrate inferred from the ages of MDACs are likely to imply re-equilibration and continuing growth of hydrates in high CH₄ and low to zero H₂S conditions during burial. Vertical and perhaps lateral flux of H₂S-free methane into gas chimneys may therefore be a major contributor to the formation of thick deposits of massive gas hydrate. This study was conducted under the commission from AIST as a part of the methane hydrate research project funded by METI (the Ministry of Economy, Trade and Industry, Japan).

Reference

[1] Matsumoto et al. (2017), *Fire in the Ice*, 17, 1-6