Sustainable generation of thermogenic CH_4/H_2 in the underthrust sediments, Nankai Trough

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Gas hydrates, mud volcanoes, and gas plumes, containing microbial and/or thermogenic CH_4, are widely distributed in the subduction zone of the Nankai Trough, showing significant CH_4 generation and emission. However, the location and rate of current CH_4 generation and the source of H_2 for microbial CH_4 production are still uncertain. We focused on the underthrust sediments below the décollement, and estimated the current generation of thermogenic CH_4 and H_2 with the subduction of the Philippine Sea Plate.

The movement and heating rate of the accretionary prism and underthrust sediments in the Kumano-nada region were estimated according to the evolution of accretionary prisms and thermal structure of the subduction zone (Saffer et al., 2008; Yoshioka et al., 2013, Sugihara et al., 2014). The TOC concentrations of the accretionary prisms and underthrust sediments have been estimated to be low about 0.5 wt% (Raimbourg et al., 2017), suggesting a little expulsion of oil and wet gas. The kinetic characteristics of thermogenic CH_4 generation was therefore evaluated based on the closed-system pyrolysis experiments. The generation of thermogenic H_2 is assumed to occur soon after the CH_4 generation as is observed for the compositional change of residual gas in pelitic rocks (Suzuki et al., 2017).

The annual generation rate of CH_4 in the underthrust sediments along the 1 km Nankai Trough was estimated to be in the order of several 10^5 m^3/yr. On the other hand, a small part of the inner prism attained the temperature more than 200ºC, showing an insufficient generation of thermogenic CH_4. The annual generation rate of CH_4 in the underthrust sediments is about 20 times higher than that in the inner prism. This is attributed to the faster subduction rate and sufficient thermal maturation of the underthrust sediments compared to the accretionary prisms. The significant generation of thermogenic H_2 in the underthrust sediments is also expected. The H_2 is generated also by water-rock interactions with the destruction of silicate rocks (Kameda et al., 2003). The thermogenic H_2 from the underthrust sediments and the H_2 generated by rock fracturing can be sustainable sources of H_2 in the subduction zone. The expulsion of thermogenic CH_4 and H_2 probably occurs intermittently due to micro and macro fracturing of rocks associated with plate movement, and releases an overpressure in the underthrust sediments. The sustainable supply of CH_4 and H_2 from the underthrust sediments in the deep subduction zone is playing significant roles for the accumulations and emissions of both thermogenic and microbial CH_4 in the subduction zone of the Nankai Trough.

References: Kameda J. et al. (2003) Geophys. Res. Lett. 30, 2063, Raimbourg, H. et al. (2017) Tectonophys. 721, 254-274, Saffer et al. (2008) Island Arc 17, 208-230, Sugihara, T. (2014) Earth Planets Space 66, 107, Suzuki, N. et al. (2017) Int J Coal Geol. 173, 227-236, Yoshioka, S. et al. (2013) Tectonophy. 608, 1094-1108.

Keywords: underthrust sediments, thermogenic methane, thermogenic hydrogen, accretionary prism, gas generation rate, subduction zone

