Geochemistry of the interstitial waters in the METI/JOGMEC Exploratory wells, in the eastern Nankai Trough, off central Japan

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The Nankai Trough runs along the off southwest Japan at the convergent margin of the Philippine Sea Plate subducting beneath the southwest Japan arc. The existence of BSRs has been extensively recognized by seismic surveys, and natural gas hydrates have been recovered in this area. In January to May 2004, METI/JOGMEC-MH21 conducted the gas hydrate exploration program including drillings, logging and long-term temperature monitering by DTS/FBG. About thousand water samples were taken from two full coring holes (T6 and A1) to study the distribution of gas hydrate and behavior of methane bearing fluids in Nankai Accretionary prism.

The well No.22 (T6-FC) is located on the Dai-ichi Tenryu Knoll, 30km southwest off Tokai area, where the double BSR is recognized. The depth of the water is 720 mbsl, and the drilling depth is ca 250 mbsf. The depth of upper BSR is 200 mbsf and lower BSR is 245 mbsf. High resistivity anomalies reveals an extensive distribution (ca 100 meter thick) gas hydrate zone above the upper BSR. Interstitial waters extracted from core sediments were analyzed for chloride, sulfate, sodium, calcium, and magnesium. The pattern of sulfate depletion is not linear, but gradual-tangential down to the depth of 24 mbsf where sulfate diminishes (SMI depth). This may imply that the sulfate depletion is controlled not only by methane-oxidation but also by organic matter degradation. Both calcium and magnesium concentrations show rapid decrease down to the SMI, and very gentle decrease below the SMI. Chloride concentration is similar to the seawater value (560 mmol/L) in shallow sediments while it increases to 700 mmol/L down to 100 mbsf. For the gas hydrate zone below 100 mbsf, the chloride concentration of waters from gas hydrate-bearing sandy sediments were anomalously low (ca 100-300 nmol/L), while gas hydrate-free muddy sediments anomalously enriched in chloride (700-800 nmol/L). Pore saturation of methane hydrate is mostly estimated to be about 65 to 80 %, which are consistent to the estimates from log resistivities.

The well No.29 and 30 (A1-FC) is located on northern flank of the Daini-Atsumi Knoll. The depth of the water is 1006 mbsl, and the drilling depth is ca 400 mbsf. The depth of BSR is 330 mbsf and high resistivity anomaly zones were recognized at two levels, 107-266 mbsf and 288-332 mbsf above the BSR. Sulfate depletion in shallow sediments is rapid-linear rather than gradual-tangential, and sulfate diminishes at about 7 mbsf (=SMI). The baseline of the chloride concentration is observed to be kept at around the seawater value, whereas the concentration is variably low within the gas hydrate zone indicating existence of gas hydrates. The volume ratio of methane hydrate within pore space at the well No.29 and 30 (A1-FC) widely ranges from 15 to 80 %.

Salts expelled from gas hydrate are concentrated in adjacent hydrate-free sediments in semi-closed system, whereas the excess salts would be flushed and washed away in open system. Contrasting profiles and behavior of chloride observed in two drill sites suggest that gas hydrate was formed in semi-closed system in the well No.22 (T6-FC) and in open system in the well No.29 and 30 (A1-FC), probably implying that the interstitial fluids in Dai-ichi-Tenryu Knoll sediments are more stagnant than the northern flank of the Dai-ni-Atsumi Knoll. The migration of the fluids may also control the methane flux and sulfate depletion pattern in shallow sediments. Behavior of subsurface gas hydrate and fluids is also discussed in term of the formation temperature and existence of double BSRs.