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Research Advances

Widespread Methane Seep Activities along the Western Slope of the Okinawa Trough, East China Sea

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Objective

The western slope of the Okinawa trough has been considered to experience important methane seep activities. Abundant terrigenous sediments supply and widely developed normal faults make this area an ideal place for methane production, methane fluids migration and associated anaerobic oxidation of methane. However, few studies have been performed to reveal the methane seep activities via pore water geochemical studies in this area. In this study, we present comprehensive geochemical data from four cores at two methane seep sites in this area to investigate the pore water geochemical anomalies involving methane seep activities and to determine the variations of methane seep activity around methane seep area.

Methods

Sediments in this study were obtained using gravity core at site 79 (79A) and piston gravity core at site 75 (75A, 75B and 75D), respectively. Pore water was squeezed by pressure filtration on board. About 6cm thick, half round core sediments were used for pore water extraction. A total of 20 mL pore water subsamples were preserved for onshore sulfate and methane determination. The headspace of the subsample was injected into a gas chromatograph (Agilent 7890). The carrier gas was nitrogen at a flow rate of 3 mL/min. Sulfate concentration was measured using Dionex 2020i ion chromatography.

Results

Pore water methane concentrations in all methane seep cores show a dramatic increase with depth. At site 79, a pronounced increase in CH_4 concentrations was found at 300 cmbsf, which were two orders of magnitude higher than those observed in background cores (Fig. 1). At site 75, CH_4 concentrations in methane seep cores show larger variations with the distance from methane seep center. In the seep center, CH_4 concentration is steady and low above the 200cmbsf in core 75B. Below this depth, CH_4 increases sharply from 2.43uM at 203cmbsf to 337.97uM at 309cmbsf (Fig. 1). At the bottom, CH_4 concentration shows a dramatic decrease down to 18.75uM, indicative of the strong degassing during the sampling. Both in core 75A and 75D, CH_4 concentration profiles show similar in shape. Within the upper 250cmbsf sediments of both cores, CH_4 concentrations remain low values less than 2uM. Below this depth, abrupt CH_4 increase exhibits from 7.07uM to 51.93uM in core 75A and from 1.55uM to 12.96uM in core 75D. In background core, CH_4 show little variation from 0.29 to 1.38uM throughout the whole sediment column .

Sulfate concentrations show different depletion trend with depth in all cores. In core 75B, sulfate concentrations show a concave-up profile within the upper 200cmbsf, followed by strong and rapid sulfate reduction with the concentration varied from 29.49mM to 0.72mM (Fig. 1). SO_4^{2-} shows little variation from 29.3 to 22.0mM in the upper 202.5cmbsf of core 75A. Below this depth, values show strong and abrupt depletion from 20.1mM to 1.9mM (Fig 1). Away from the methane seep center, SO_4^{2-} in core 75D maintains a narrow range from 28.75mM to 24.45mM within the upper 322.5cmbsf. Abrupt SO_4^{2-} decrease occurs at the bottom of this core. In the background core, SO_4^{2-} shows little variation from 27.40mM to 25.20mM throughout the entire core. At site 79, SO_4^{2-} exhibits larger variations from 31.86 to 6.32 mM. Sulfate profiles display a linear decrease from

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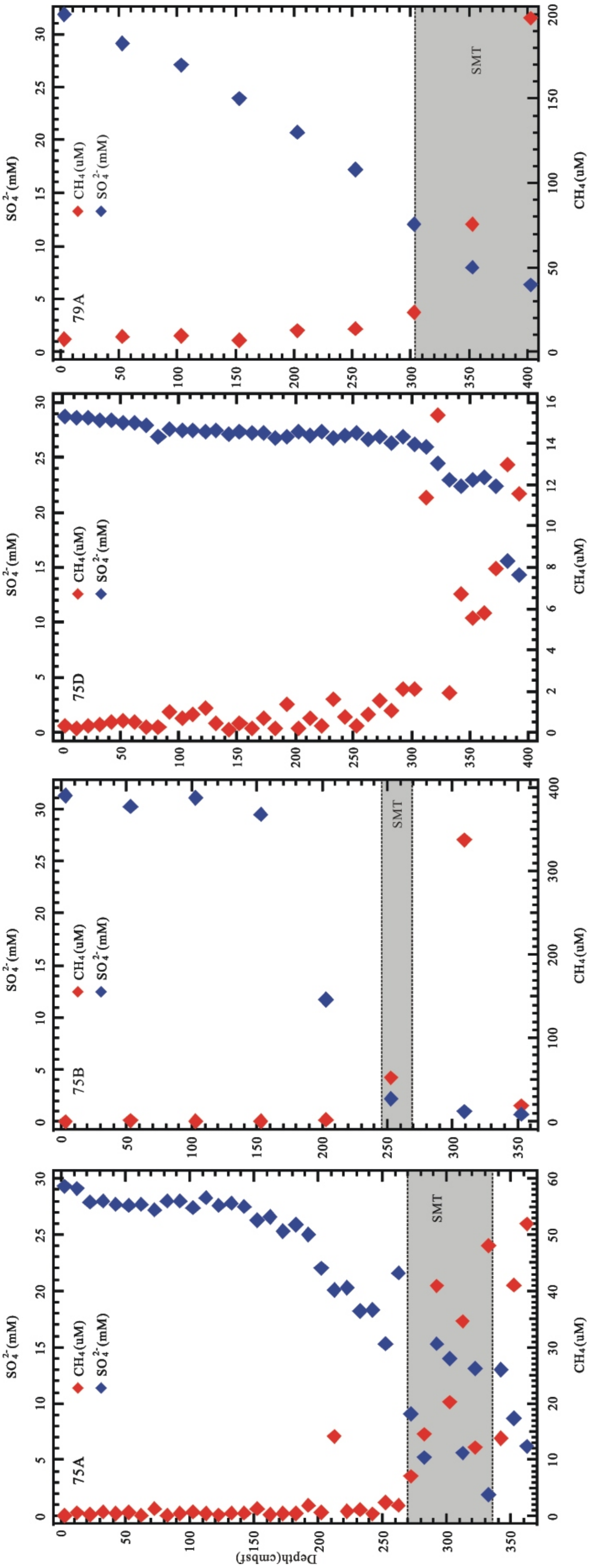

Fig. 1. Profiles showing methane and sulfate concentration of pore water. The Core 75B was taken inside the methane seep center. The Cores 75A and 75D were taken away from the methane seep center, but still inside the methane seep area. The shaded zones indicate the sulfate-methane transition (SMT) zones.

sediment surface down to the bottom of the core 79A (Fig. 1).

Conclusions

Downward steep sulfate reductions, intense methane concentration increases all indicate extensive AOM activities at methane seep sites in the Okinawa trough. Active methane seep and strong methane upward fluid compress the sulfate methane interface (SMI) depth and move it closer to the sediment surface (Fig. 1).

Spatial pore water methane and sulfate concentrations differences around methane seep areas reveal methane seep activities variations within and surrounding the methane seep center. Inside the methane seep area, shallower SMI depth indicates strong methane fluid migration, sulfate reduction and active methane seep activities (Fig. 1). Deeper SMI depths inferred from cores away from the methane seep center demonstrate weak methane seep activities and associated AOM.

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