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Geological and morphological setting of 2778 methane seeps in the Dnepr paleo-delta, northwestern Black Sea

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Abstract

The Dnepr paleo-delta area in the NW Black Sea is characterized by an abundant presence of methane seeps. During the expeditions of May–June 2003 and 2004 within the EU-funded CRIMEA project, detailed multibeam, seismic and hydro-acoustic water-column investigations were carried out to study the relation between the spatial distribution of methane seeps, sea-floor morphology and sub-surface structures.

2778 new methane seeps were detected on echosounding records in an area of 1540 km^2. All seeps are located in the transition zone between the continental shelf and slope, in water depths of 66 to 825 m. The integration of the different geophysical datasets clearly indicates that methane seeps are not randomly distributed in this area, but are concentrated in specific locations.

The depth limit for the majority of the detected seeps is 725 m water depth, which corresponds more or less with the stability limit for pure methane hydrate at the ambient bottom temperature (8.9 °C) in this part of the Black Sea. This suggests that, where gas hydrates are stable, they play the role of buffer for the upward migration of methane gas and thus prevent seepage of methane bubbles into the water column.

Higher up on the margin, gas seeps are widespread, but accurate mapping illustrates that seeps occur preferentially in association with particular morphological and sub-surface features. On the shelf, the highest concentration of seeps is found in elongated depressions (pockmarks) above the margins of filled channels. On the continental slope where no pockmarks have been observed, seepage occurs along crests of sedimentary ridges. There, seepage is focussed by a parallel-stratified sediment cover that thins out towards the ridge crests. On the slope, seepage also appears in the vicinity of canyons (bottom, flanks and margins) or near the scarps of submarine landslides where mass-wasting breaches the fine-grained sediment cover that acts as a stratigraphic seal. The seismic data show the presence of a distinct "gas front," which has been used to map the depth of the free gas within the sea-floor sediments. The depth of this gas front is variable and locally domes up to the sea floor. Where the gas front approaches the seafloor, gas bubbles were detected in the water column. A regional map of the sub-surface depth of the gas front emphasises this "gas front-versus-seep" relationship.

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