Marine Geology xxx (2008) xxx-xxx

Contents lists available at ScienceDirect

Marine Geology

journal homepage: www.elsevier.com/locate/margeo

Anomalous sea-floor backscatter patterns in methane venting areas, Dnepr paleo-delta, NW Black Sea

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ARTICLE INFO

Article history:
Received 9 July 2007
Received in revised form 25 February 2008
Accepted 4 March 2008
Available online xxxx

Keywords:
methane seeps
acoustic sea-floor backscatter
anaerobic oxidation of methane
bacterial mats
pockmarks
methane-derived authigenic carbonates

ABSTRACT

The relation between acoustic sea-floor backscatter and seep distribution is examined by integrating multibeam backscatter data and seep locations detected by single-beam echosounder. This study is further supported by side-scan sonar recordings, high-resolution 5 kHz seismic data, pore-water analysis, grain-size analysis and visual sea-floor observations. The datasets were acquired during the 2003 and 2004 expeditions of the EC-funded CRIMEA project in the Dnepr paleo-delta area, northwestern Black Sea.

More than 600 active methane seeps were hydroacoustically detected within a small (3.96 km by 3.72 km) area on the continental shelf of the Dnepr paleo-delta in water depths ranging from −72 m to −156 m. Multibeam and side-scan sonar recordings show backscatter patterns that are clearly associated with seepage or with a present dune area. Seeps generally occur within medium- to high-backscatter areas which often coincide with pockmarks.

High-resolution seismic data reveals the presence of an undulating gas front, i.e. the top of the free gas in the subsurface, which domes up towards and intersects the sea floor at locations where gas seeps and medium- to high-backscatter values are detected. Pore-water analysis of 4 multi-cores, taken at different backscatter intensity sites, shows a clear correlation between backscatter intensity and dissolved methane fluxes. All analyzed chemical species indicate increasing anaerobic oxidation of methane (AOM) from medium- to high-backscatter locations. This is confirmed by visual sea-floor observations, showing bacterial mats and authigenic carbonates formed by AOM. Grain-size analysis of the 4 multi-cores only reveals negligible variations between the different backscatter sites.

Integration of all datasets leads to the conclusion that the observed backscatter patterns are the result of ongoing methane seepage and the precipitation of methane-derived authigenic carbonates (MDACs) caused by AOM. The carbonate formation also appears to lead to a gradual (self)-sealing of the seeps by cementing fluid pathways/horizons followed by a relocation of the bubble-releasing locations.

1. Introduction

In recent years, considerable research efforts have been invested to gain a better understanding of how methane emissions from natural marine gas seeps contribute to the global atmospheric methane budget (Hovland et al., 1993; Hornafius et al., 1999; Dimitrov, 2002; Etiope and Klusman, 2002; Etiope, 2004; Judd, 2004; Kvenvolden and Rogers, 2005; Luyendyk et al., 2005). Given that methane is a potent greenhouse gas, with 21–23 times the global warming potential as the same mass of carbon dioxide (Lelieveld et al., 1998; IPCC, 2001b), a correct assessment of all natural sources is essential to better evaluate the human impact on global atmospheric methane concentrations and consequently on global climate change (IPCC, 2001a).

The amount of methane released by natural gas seeps from the sea floor, into the water column and possibly into the atmosphere, is highly variable and remains — despite several attempts at quantification — largely unknown, even for small well-studied areas (Hovland et al., 1993; Hornafius et al., 1999; Dimitrov, 2002; Etiope and Klusman, 2002; Etiope, 2004; Judd, 2004; Kvenvolden and Rogers, 2005; Luyendyk et al., 2005; Bange, 2006; Kessler et al., 2006). Current estimates of global methane fluxes from the seabed to the atmosphere vary between 0.4 and 48 Tg yr^{-1} (Judd, 2004), i.e. over two orders of magnitude. The main problems in establishing reliable estimates of regional and global fluxes are the uncertainties regarding i) the total area involved in active seepage, and ii) the temporal variability in seep intensity and activity.

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doi:10.1016/j.margeo.2008.03.002