Geophysical Research Abstracts, Vol. 7, 05386, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05386

Study of methane flux in rapidly accumulating marine sediments using radiocarbon dating - Data from the 200 m deep Skagen-3 well, Denmark

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Indications of methane emissions from the Pleistocene, including plumes and seeps as well as carbonate crusts, have been observed in marginal areas of the Kattegat basin, the centre of which is dominated by thick gas-charged Holocene deposits, containing methane of a more recent origin. Gas emissions from older layers occur where Holocene deposits wedge out, particularly to the east and south where Pleistocene deposits are thickest. To be able to model the fluxes and the emissions of methane from the marine environment, the aim of the EU METROL project, it is important to know to what extent methane from these older deposits contribute to the younger gassy sediments in the Kattegat area. For this purpose, methane ages were compared with sediment ages as well as organic matter ages in the 115 m thick section of Holocene deposits penetrated by the Skagen-3 well. The purpose of this 200 m deep well drilled close to the shore of the Kattegat in northernmost Denmark was to determine the geotechnical properties of the rapidly accumulating sediments in this area.

124 cores of undisturbed sediments were recovered from the well. The 1.5 m cores were retrieved in 10 cm diameter plastic liners that were immediately sealed for later geo-technical and geological examination. At the well site, gas was extracted from the sediment by a non-destructive method involving the connection of a 60 ml syringe to the core liner through a 4 mm hole, which was sealed just after the operation. Gas (1–90 ml), mostly methane, was obtained from 79 of the cores.

Radiocarbon dating of methane from 13 cores (33–146m) covering the Holocene (9) and the uppermost Pleistocene (4) indicates a regular increase in the age of the methane with depth. However, the methane is generally older than the sediment by 1000–2500 years. This may be attributed to the age of organic matter, the source of

the methane, which is older than the sediment by 4000–5000 years. Stable isotopic values of most methane samples range from δ^{13}C = -64 per mille to -78 per mille, although a marked shift from -92 per mille to -69 per mille is seen at the transition from the Pleistocene to the Holocene, which may indicate carbon cycling. The organic-rich marine Eemian deposits, the source of methane seeps elsewhere, make up only 5 m of the Pleistocene sediments at the Skagen-3 location, the rest being organic-poor sandy sediments. It is concluded, therefore, that Pleistocene sediments contribute only negligible quantities of methane to the Holocene sediments above.