DOI 10.1007/s12182-013-0265-6

Methane in soil gas and its transfer to the atmosphere in the Yakela condensed gas field in the Tarim Basin, Northwest China

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Abstract: In this study, by analyzing CH_4 concentration and $\delta^{13}C_{CH_4}$ in soil-gas profiles, the potentials of CH_4 gas transfer from ground to atmosphere were studied at four representative sectors in the Yakela condensed gas field in the Tarim Basin, Xinjiang, China. These are: 1) the oil–gas interface sector, 2) fault sector, 3) oil–water interface sector, 4) an external area. Variation in CH_4 in soil-gas profiles showed that CH_4 microseepage resulted from the migration of subsurface hydrocarbon from deep-buried reservoirs to the earth's surface. It was found that CH_4 from deep-buried reservoirs could migrate upwards to the surface through faults, fissures and permeable rocks, during which some CH_4 was oxidized and the unoxidized methane remained in the soil or was emitted into the atmosphere. The lowest level of CH_4 at the soil-gas profile was found at the CH_4 gas-phase equilibrium point at which the CH_4 migration upwards from deep-buried reservoirs and the CH_4 diffusion downwards from the atmosphere met. The $\delta^{13}C_{CH_4}$ and ethane, propane in soil gas exhibited thermogenic characteristics, suggesting the occurrence of CH_4 microseepage from deep-buried reservoirs. A linear correlation analysis between CH_4 concentrations in soil gas and temperature, moisture, pH, Eh, Ec and particle size of soil indicated that both soil Eh and soil temperature could affect CH_4 concentration in soil gas while soil pH could indirectly influence soil methanotrophic oxidation via impacting soil Eh.

Key words: Soil gas, CH_4 concentration, carbon isotope, microseepage, oil reservoir

1 Introduction

During the past two decades, geologic CH_4 emission has always been considered as a negligible contributor to CH_4 concentration in the atmosphere. According to the Second and Third IPCC Assessment Report (Lelieveld et al, 1998), methane hydrate was found to be a minor source of natural geologic methane, only accounting for about 0.9% of the total atmospheric methane budget. However, recent studies have shown that natural geologic emissions of CH_4 could play an important role in the atmospheric methane budget, mainly due to CH_4 emissions from petroleum seepage through faults, fissures and permeable rocks, mud volcanism, marine seeps and geothermal manifestations. Meanwhile, these geologic CH_4 emissions may represent an important component of the 'missing' source of fossil CH_4 (radiocarbon-free), as recently recognized in the atmospheric budget (Etiope et al, 2008). In the Fourth Assessment Report of IPCC, geological CH_4 sources have been considered as the second highest natural source for CH_4 emissions after wetlands, while geological seepage has been recognized as a new category in the UNECE/EMEP Task Force Emission Inventory Guidebook (Etiope, 2009; Etiope et al, 2008; Etiope and Ciccioli, 2009; Etiope and Klusman, 2010).

During the 1920s and 1930s, studies suggested that a close correlation existed between concentration anomalies of hydrocarbon gases near the surface of the earth and deep-buried oil and gas reservoirs. Soil gas methane has been an important indicator of deep-buried reservoirs (Laubmeyer, 1933; Klusman, 1993; Hunt, 1996; Abrams, 2005). It was not until recently that numerous field surveys have been conducted on CH_4 flux from petroleum-bearing sedimentary basins by researchers in the USA, Europe (Italy, Germany, Greece), and Asia (Azerbaijan, China) (Klusman and Jakel, 1998; Thielemann et al, 2000; Etiope, 2004; 2009; Etiope and Milkov, 2004; Yang et al, 2004; Tang et al, 2007; 2008; 2009; 2010; Etiope and Ciccioli, 2009; Etiope and Klusman, 2010). Now, it has become an international research focus that microseepage of hydrocarbon gas throughout the area related to petroleum-bearing sedimentary basins is an important source of atmospheric CH_4. Microseepage capacity of hydrocarbon gas from deep-buried reservoirs is influenced

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Received October 12, 2012