# Modeling Timing and Distribution of Biogenic Gas Generation in the Plio-Pleistocene Eridanos Delta, Dutch Offshore*

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## Abstract

Shallow gas accumulations in the Plio-Pleistocene Eridanos Delta deposits in the Dutch offshore may represent a valuable additional hydrocarbon source, especially if located near existing infrastructure. Shallow gas production in the Dutch offshore is still limited due to a lack of understanding of these gas systems. One of the requirements for understanding these gas systems concerns knowledge on the origin of the gas. The origin may be biogenic sources within the shallow strata or deeper thermogenic sources. We used a combination of modeling approaches for simulating the timing of biogenic gas generation and identifying the location of the charging areas of biogenic shallow gas in the Eridanos Delta deposits. These modeling efforts are part of ongoing integrated research aiming to assess a detailed 3D basin-scale model of the Eridanos Delta and its relation to shallow gas accumulations in time and space (Verweij et al., 2012). We will present preliminary results of the modeling study. The workflow developed during this study is also applied to investigate – paleo – generation of biogenetic gas as a source for shale gas accumulations.

## Biogenic and Thermogenic Origin of Shallow Gas

Current knowledge on the origin of shallow gas accumulations in the Dutch offshore is based on a limited number of publicly available analyses of geochemical and isotopic composition of shallow gas accumulations and on seismic indicators of fluid migration paths and gas accumulations. Most of the analyses of the geochemical and isotopic composition of shallow gas in the northern Dutch offshore show typical characteristics of biogenic gas: the gas is very dry and depleted in 13C/C. Some analyses, however, indicate that gas from thermogenic origins has entered the shallow deposits. Inventory of bright spots (DHI direct hydrocarbon indicators for shallow gas) showed that many of the potential gas occurrences occur in stratigraphic traps or above salt domes (Schroot, 2005; Verweij et al., 2012). Seismic attribute analyses

revealed that salt structures and faults are important in conducting fluids (water and/or gas) from deeper levels. These indicators of present or past fluid migration paths point to possible deeper – thermogenic and/or biogenic – sources of gas.

A biogenic origin appears to be an important source of the shallow gas accumulations. It is not known where and when biogenic generation of gas occurred and how much was generated in the Dutch subsurface. By using a combination of modeling approaches we aim to answer these questions related to the shallow gas in the Eridanos Delta deposits. Topics investigated include:

- What is the impact of the surface temperature fluctuations during the last 3 My on subsurface temperature distribution and biogenic gas generation (Figure 1)?
- Where and when did biogenic gas generation take place?
- How much gas was generated?
- What is the relation between charging areas and regional changes in thickness and characteristics of the Eridanos Delta?

## Modeling Approach

The 1D modeling is performed on selected well locations with detailed information and a number of virtual well locations covering the distribution area of the Eridanos Delta. The workflow includes three main phases:

1. Pilot project to determine the amount of detail needed for the 1D basin modeling and biogenic gas generation modeling with regard to layering, lithology, chronology, thermal boundary conditions, and to determine the need for including biogenic gas generation modeling at paleo times. Part of the pilot project focuses on the evaluation of the influence of rapid surface temperature fluctuations during the last 3 Myrs on biogenetic gas generation;

2. 1D basin modeling (using Petromod). For most wells we used 1D extractions of existing 3D basin models of the Dutch offshore (covering Carboniferous to recent deposits). The 1D basin modeling results provide input data for 1D modeling of biogenic gas generation, such as current and paleo geothermal gradient, sedimentation rate, lithology, SWI temperature (Figure 2);

3. 1D modeling of biogenic gas generation in Cenozoic sediments, with focus on the Eridanos Delta deposits (using Biogenix; Clayton, 2010) (Figure 3).

## References Cited

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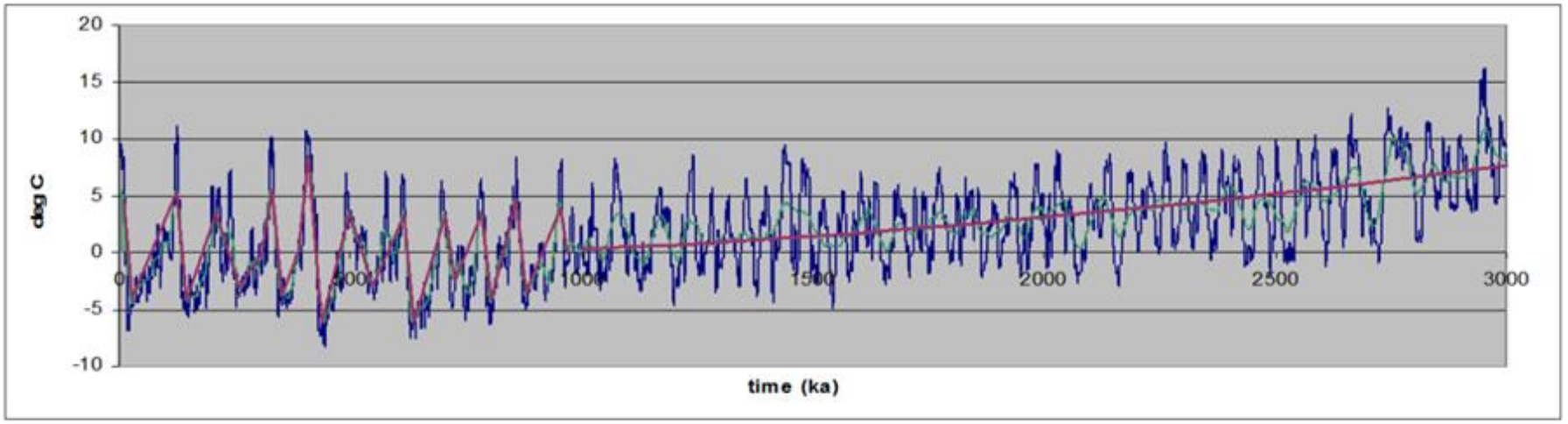


Figure 1. Rapidly changing surface temperatures during the last 3 million years (generalized red line indicates the surface temperature input for 1D Petromod modeling to assess impact on subsurface temperature distribution).

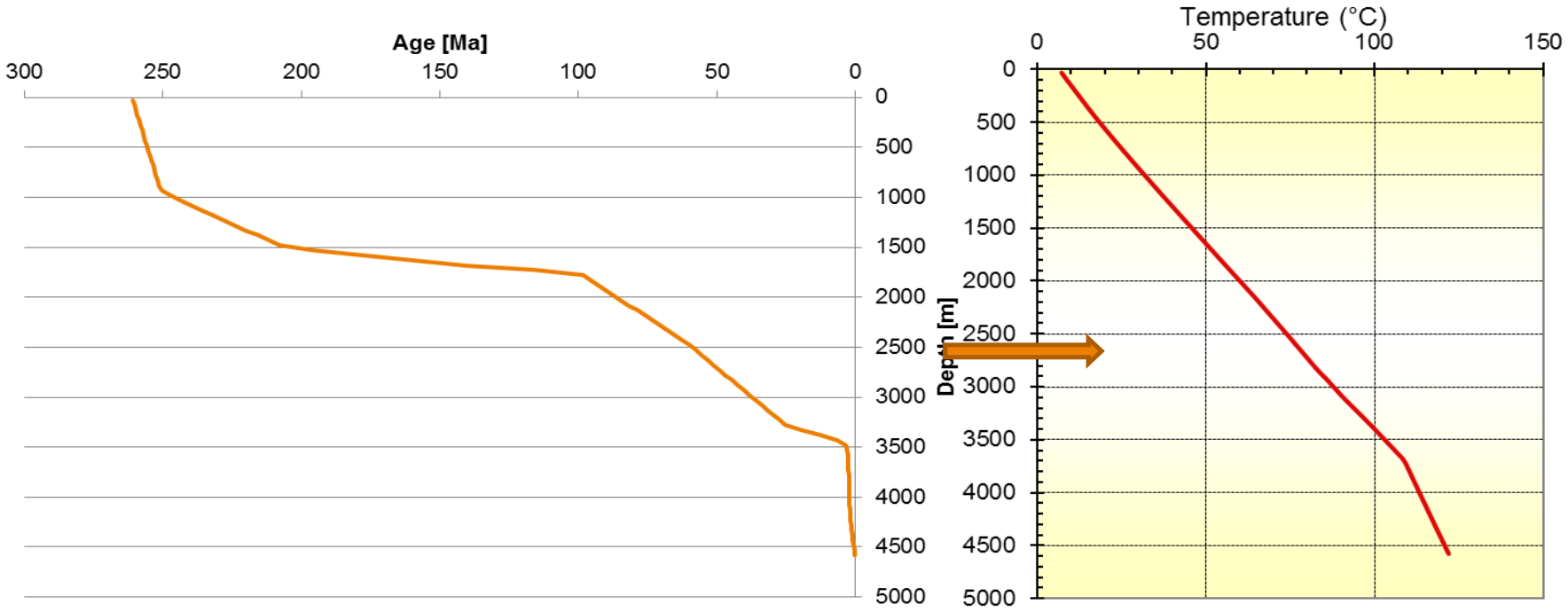


Figure 2. 1D extraction of burial history of 3D basin model (Petromod) provides input data for 1D modeling of biogenic gas generation (Biogenix; Clayton, 2010), such as geothermal gradient, sedimentation rate, lithology, SWI temperature.

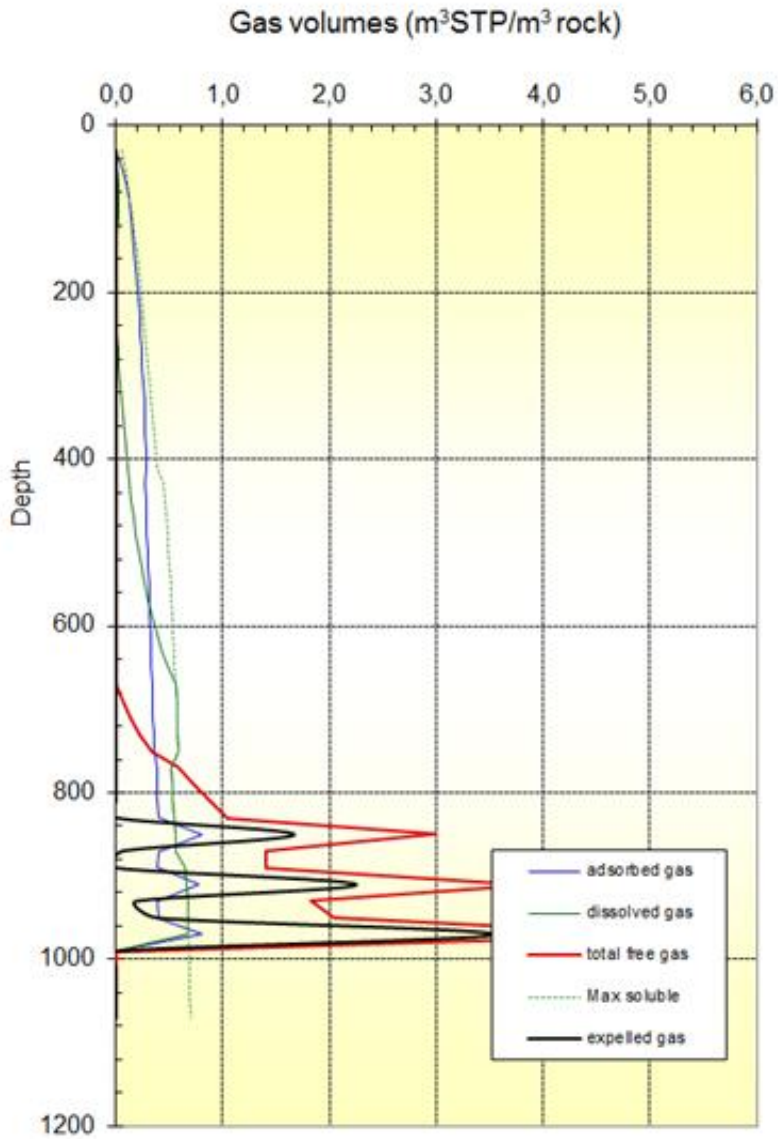


Figure 3. Example calculation of 1D modeling of biogenic gas generation using Biogenix (Clayton, 2010) for generalized conditions at a well in northern Dutch offshore. Conditions include: sedimentation rate = 300 m/My; temperature gradient = 30° C/km; SWI temperature = 9° C; TOC = 0.5%; in 3 layers TOC = 1%.