

# Origin and Alteration of Natural Gas and Liquid Hydrocarbons in the Austrian Molasse Basin\*

L. Pytlak<sup>1</sup>, D. Groß<sup>1</sup>, A. Bechtel<sup>1</sup>, R. Gratzer<sup>1</sup>, R.F. Sachsenhofer<sup>1</sup>, H.-G. Linzer<sup>2</sup>, M.-L. Grundtner<sup>1</sup>, and L. Scheucher<sup>2</sup>

Search and Discovery Article #10667 (2014)\*\*

Posted November 17, 2014

\*Adapted from oral presentation given at AAPG International Conference & Exhibition, Istanbul, Turkey, September 14-17, 2014

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<sup>1</sup>Department Applied Geosciences and Geophysics, Montanuniversitaet Leoben, Leoben, Austria ([lukasz.pytlak@unileoben.ac.at](mailto:lukasz.pytlak@unileoben.ac.at))

<sup>2</sup>Rohöl-Aufsuchungs AG, Wien, Austria

## Abstract

The Molasse Basin, extending from Geneva to Vienna, is the northern foreland basin of the Alps and comprises Eocene to Miocene shallow to deep marine sediments. Within the Austrian sector, two petroleum systems can be distinguished: a thermal petroleum system comprising Lower Oligocene source and Cenomanian and Eocene reservoir rocks; a biogenic gas system in Oligocene and Miocene strata. However, geochemical data suggest a mixing of thermogenic and biogenic hydrocarbons in these horizons. The aim of the present study is to understand the origin, migration and alteration of natural gas and condensate in the Molasse Basin. To reach this goal several natural gas samples non-associated and associated with oil were analyzed for molecular and isotopic composition as follows:  $^{12}\text{C}/^{13}\text{C}$  in  $\text{CH}_4$ ,  $\text{C}_2\text{H}_6$ ,  $\text{C}_3\text{H}_8$ ,  $\text{C}_4\text{H}_{10}$  and  $\text{CO}_2$ ;  $^1\text{H}/^2\text{H}$  ratios in  $\text{CH}_4$  have also been determined. Additionally twelve condensate samples were examined for biomarkers and specific compounds composition as well as carbon isotopic composition of individual n-alkanes and acyclic isoprenoids. Oil associated gas samples contain methane (68.2–91.6 vol.%) and higher hydrocarbons (up to hexane) with small amount of nitrogen and traces of carbon dioxide. Carbon isotopic composition in methane ranges from  $-68.2\text{\textperthousand}$  PDB to  $-39.6\text{\textperthousand}$  PDB showing that next to typical thermogenic gas ( $\delta^{13}\text{C} > -45\text{\textperthousand}$ ) isotopically light methane occurs, formed most probably due to biodegradation of pre-existing oils. In contrast, the primary biogenic gas from Oligo/Miocene deposits consists almost exclusively of methane (96.2–98.7 vol %) with carbon isotopic composition ranging between  $-48.5\text{\textperthousand}$  PDB and  $-65.3\text{\textperthousand}$  PDB. Isotopically heavy carbon in methane, occurrence of wet gas components (higher hydrocarbons) and locally even liquid hydrocarbons in immature formations indicate mixing with thermogenic hydrocarbons from deeper stratigraphic units. Coexistence of strongly altered condensates with primary bacterial dry gas in reservoir rocks with relatively low temperature (below 60°C) supports the concept of methane

generation due to biodegradation of higher hydrocarbons. The results of the on-going project point out that geochemical characteristics of gas fields in the Molasse Basin are a result of interplay of different processes, like thermogenic gas generation, primary (from solid organic matter) and secondary biogenic gas generation (from biodegradation of pre-existing oils), migration and mixing processes.

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H.-G. Linzer<sup>2</sup>, M.-L. Grundtner<sup>1</sup>, L. Scheucher<sup>2</sup>

<sup>1</sup>Chair Petroleum Geology, Montanuniversitaet Leoben

<sup>2</sup>Rohöl-Aufsuchungs AG

\* Contact author: *E-mail:* [Lukasz.Pytlak@unileoben.ac.at](mailto:Lukasz.Pytlak@unileoben.ac.at)

# Content:

**1. Geology**

**2. Experimental**

**3. Results**

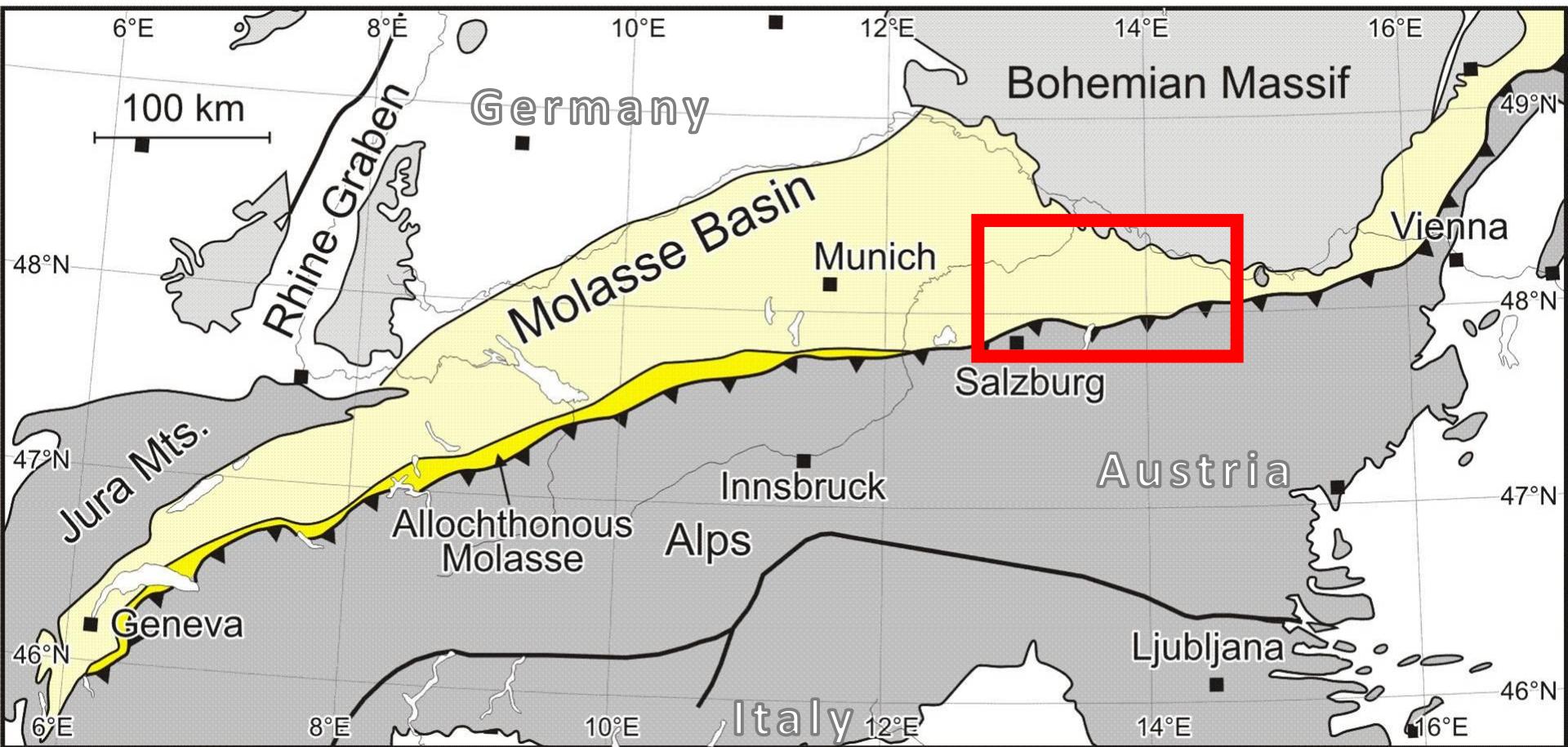
**3a. Oil/gas deposits**

**3b. Gas deposits**

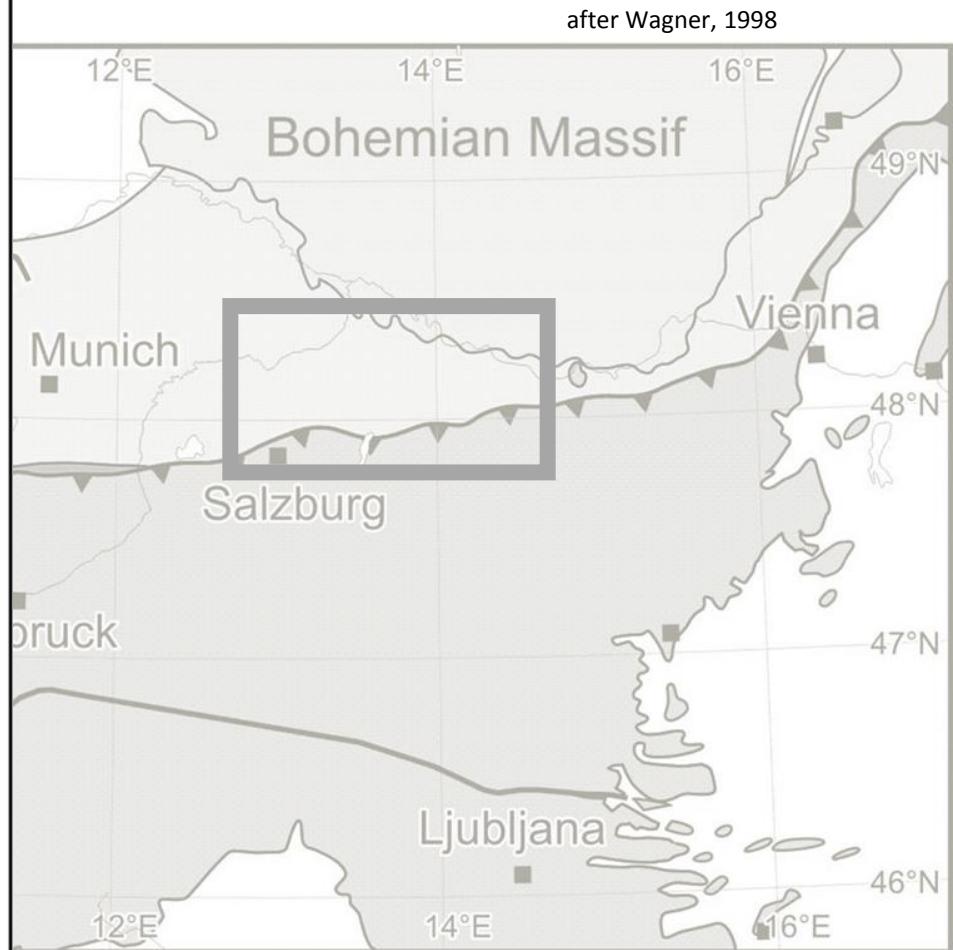
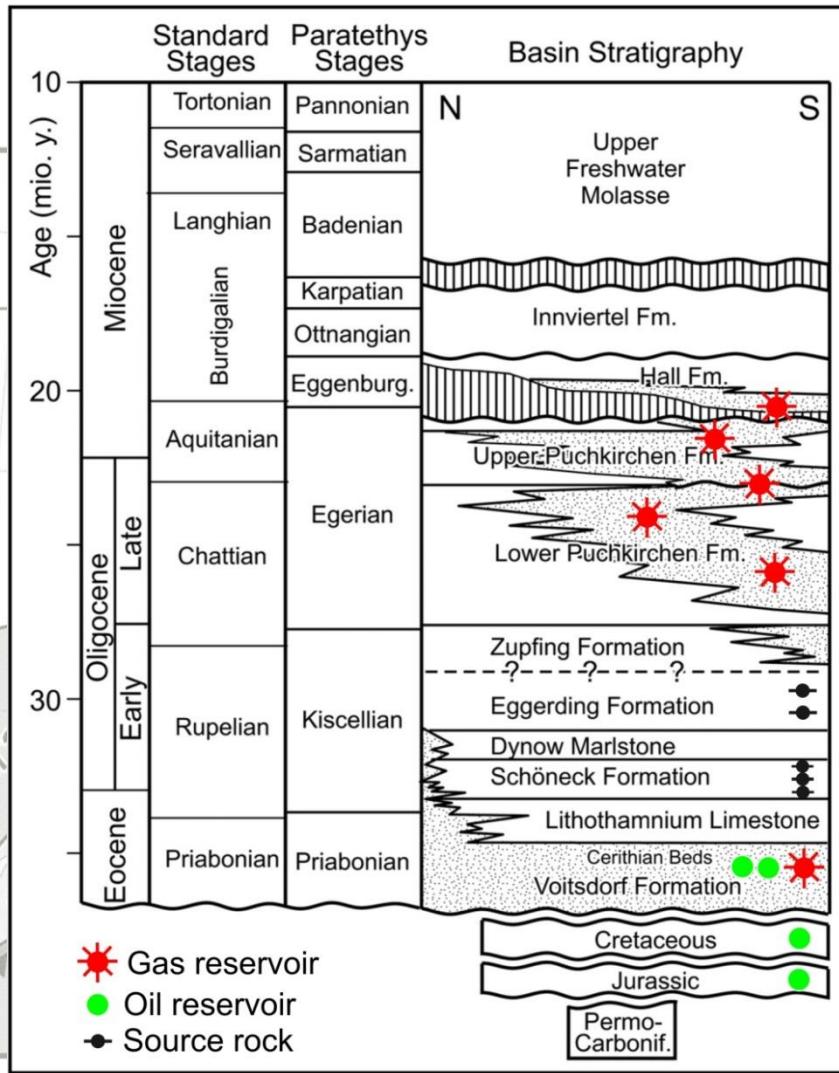
**3c. Migration model**

**4. Conclusions**

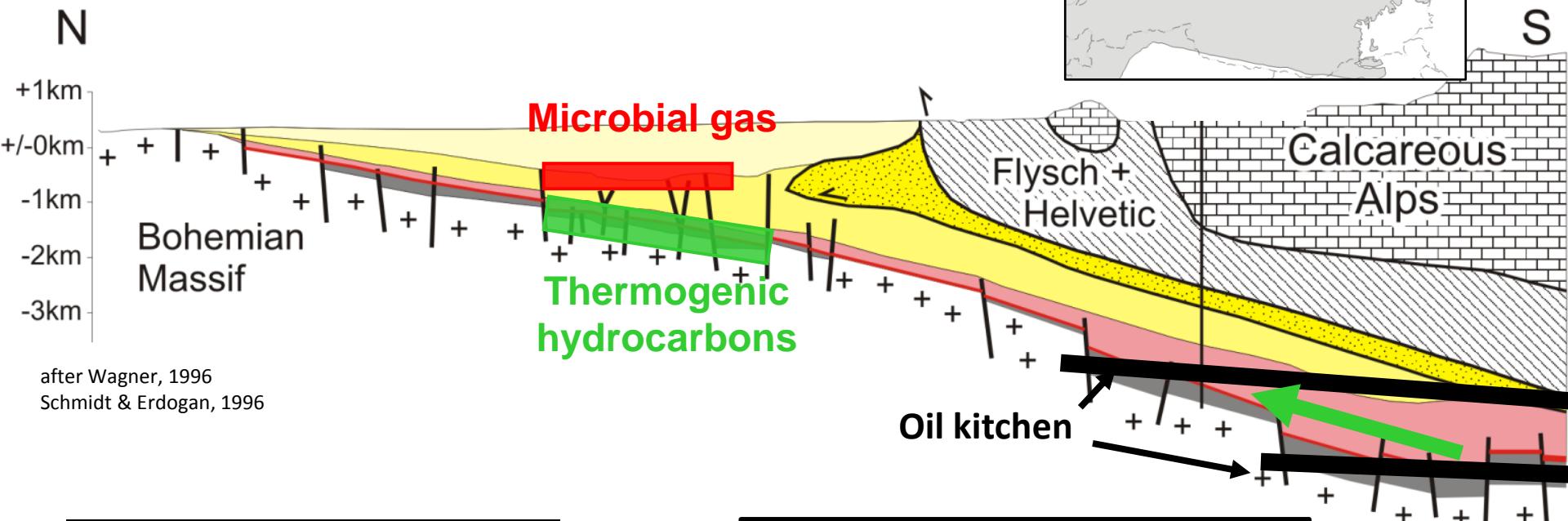
# Study Area - Austrian Molasse Basin



# Stratigraphy

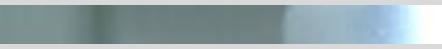


# Hydrocarbon Systems



Oligocene/Miocene → **Puchkirchen / Hall Fm**  
 Oligocene → **Cretaceous / Voitsdorf Fm**

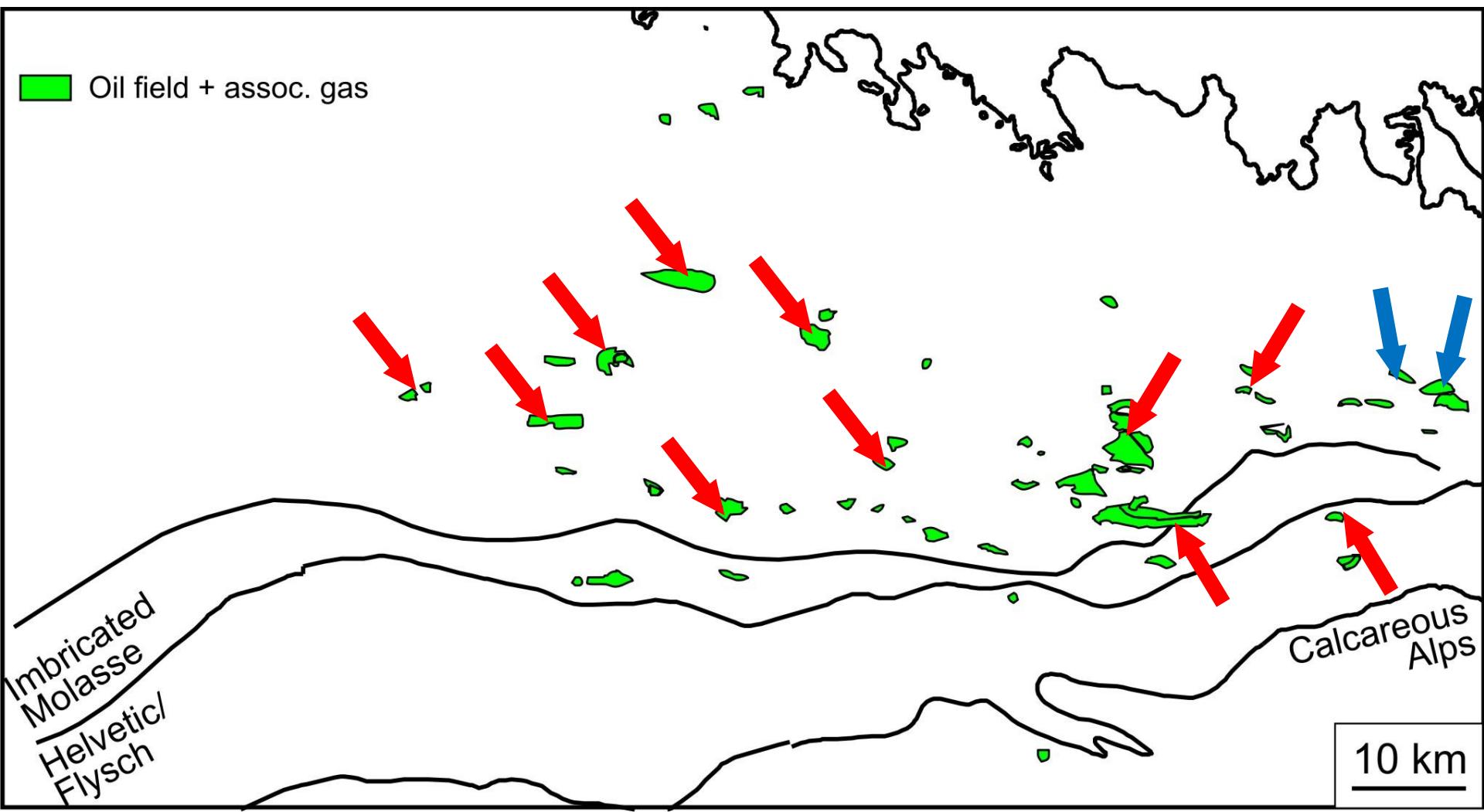
# Gaseous/liquid samples

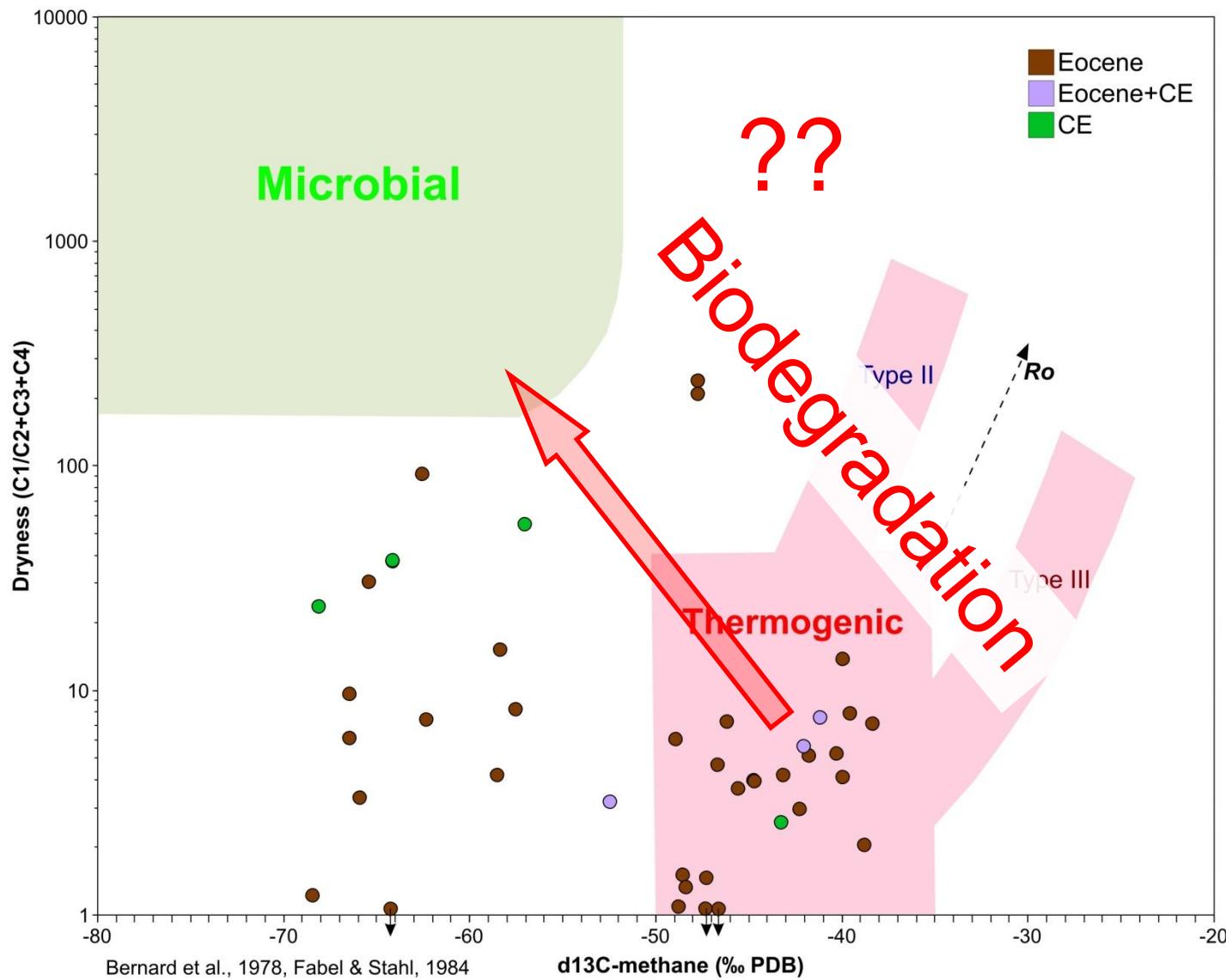


Molecular composition:  
**Gas Chromatography-MS, FID, TCD, FPD**

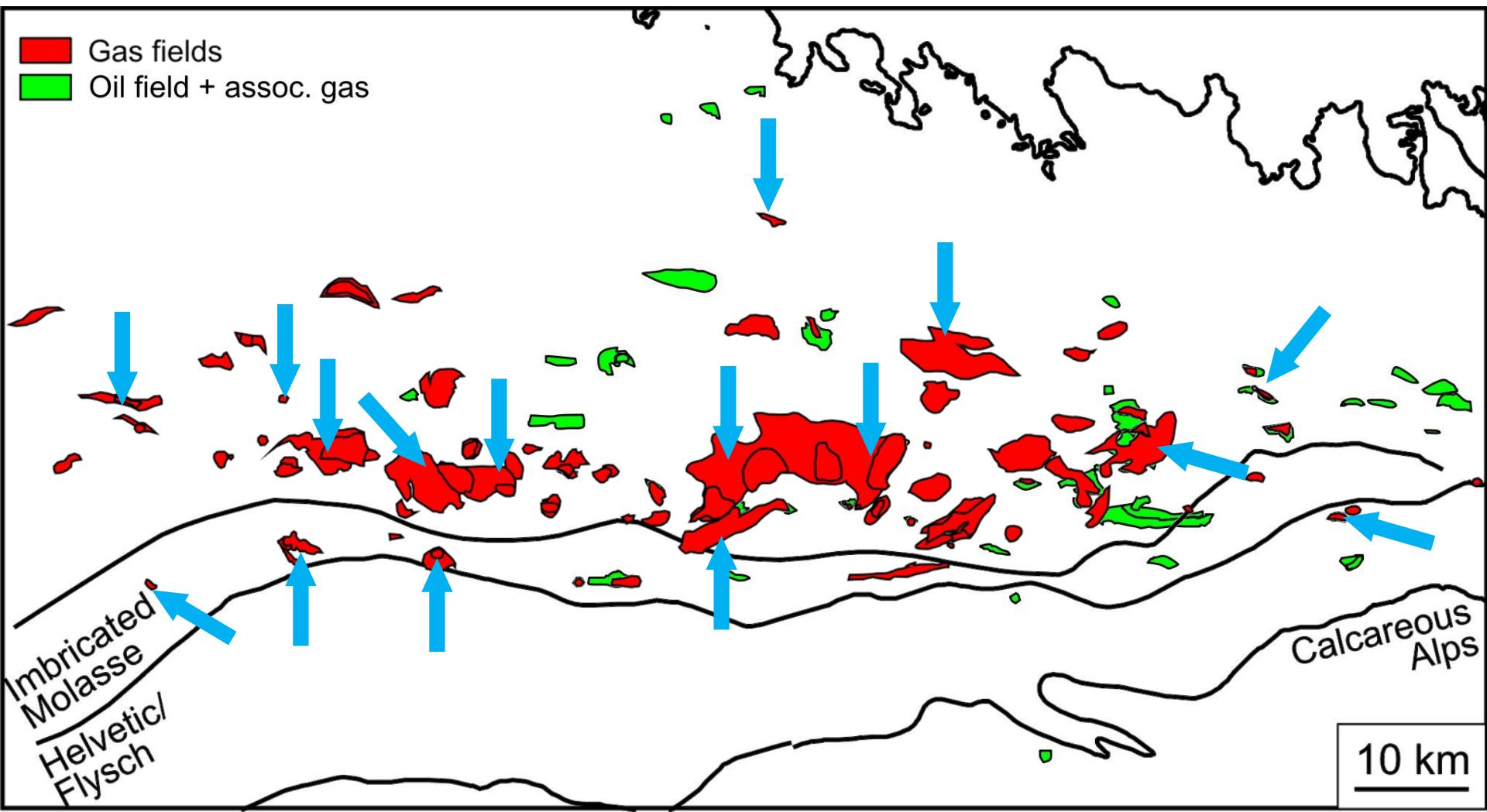
Stable C and H isotope composition:  
**Gas Chromatography-Isotope-Ratio  
Mass Spectrometry**

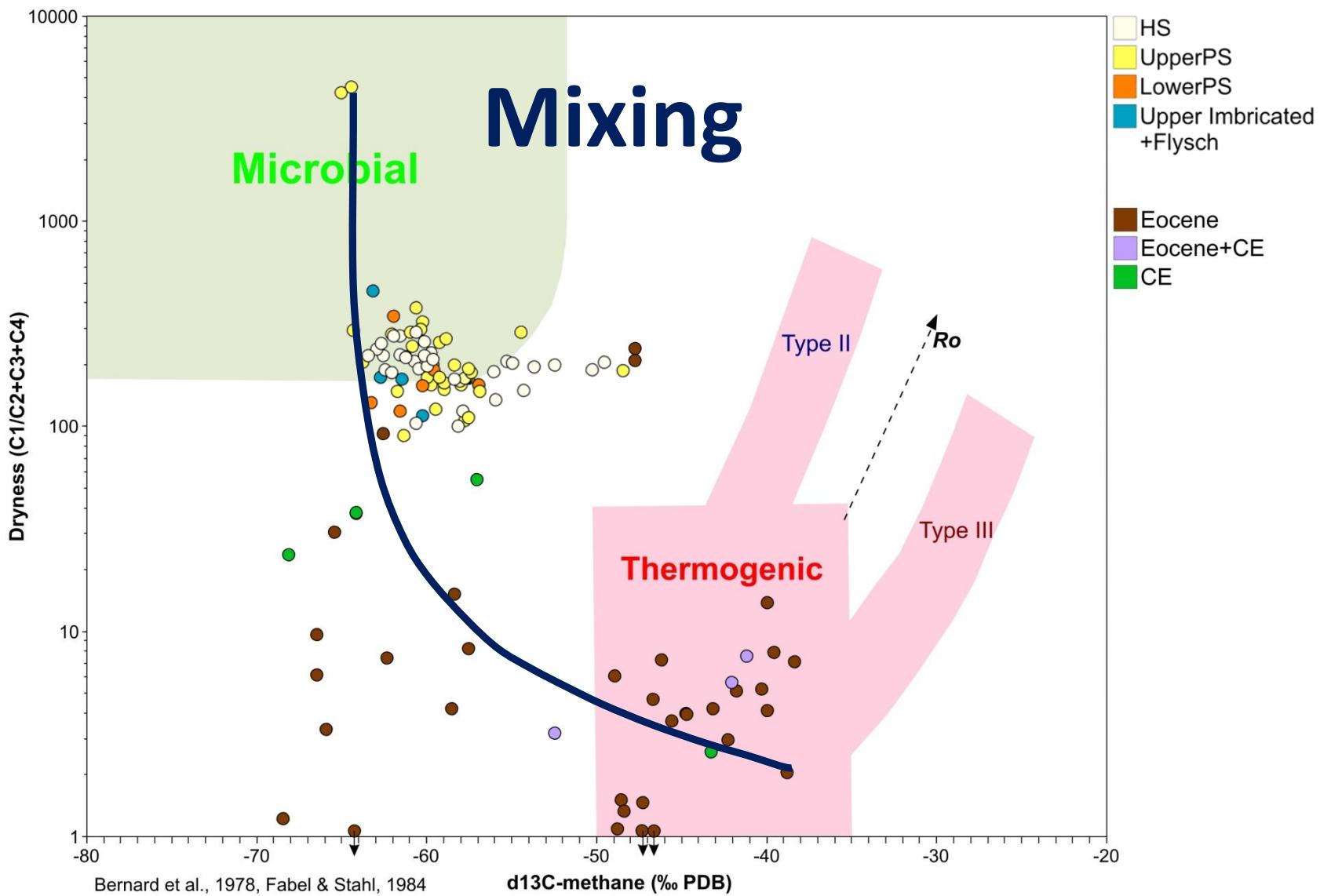
# Oil and associated gas fields – Cr/Eocene



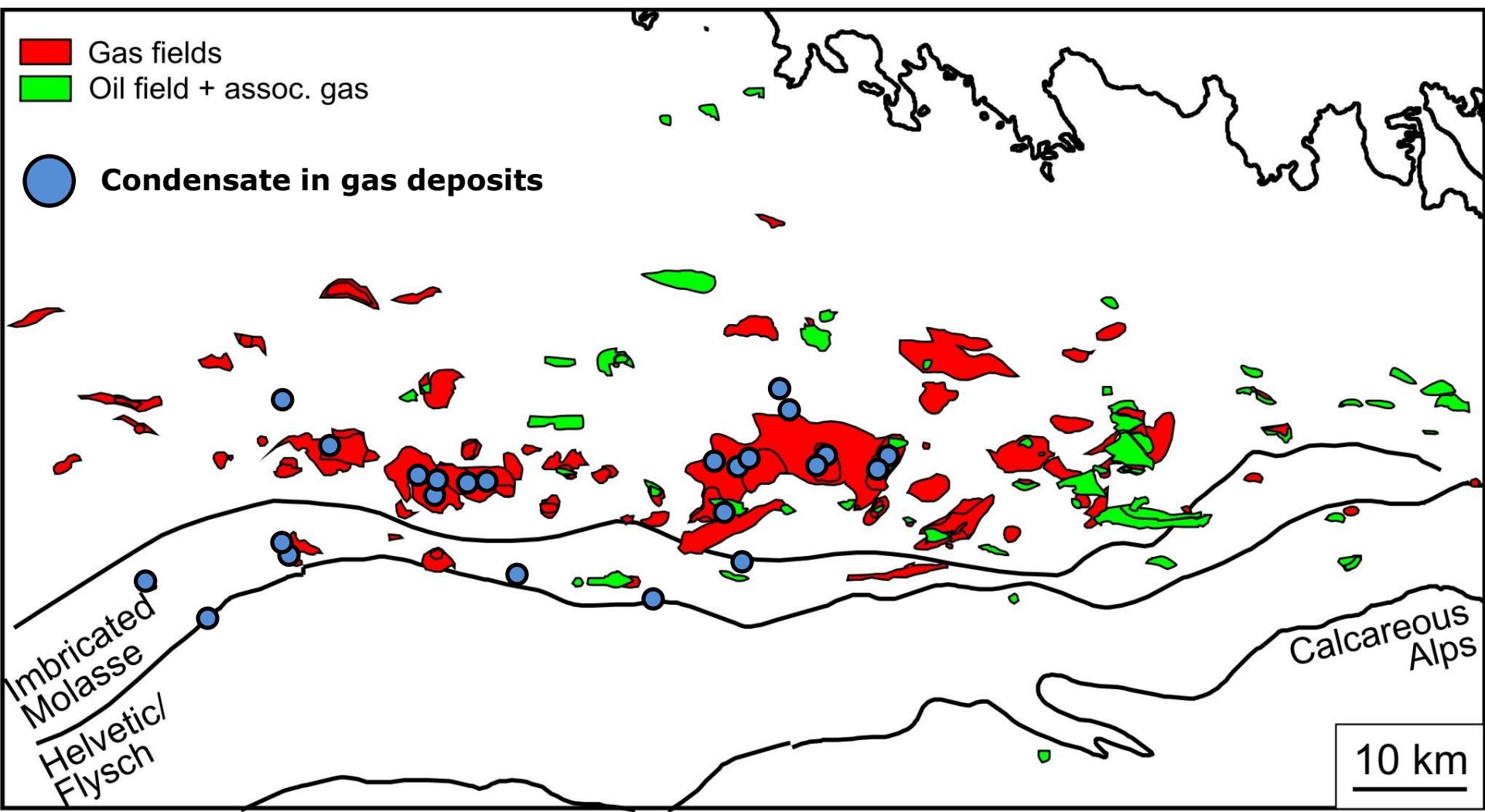


# Gas fields – Oligocene/Miocene



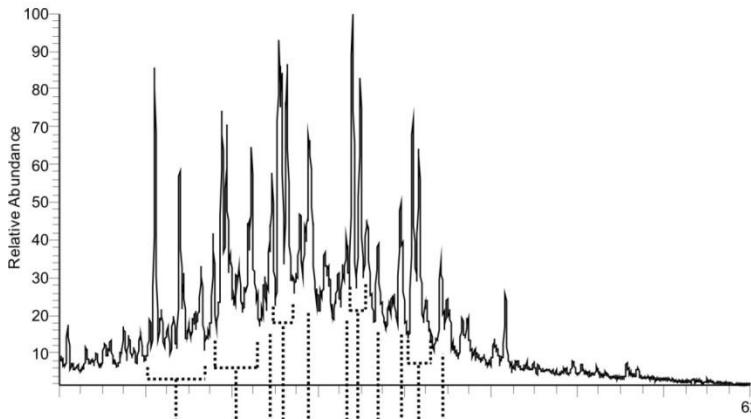


# Oil-condensate correlation

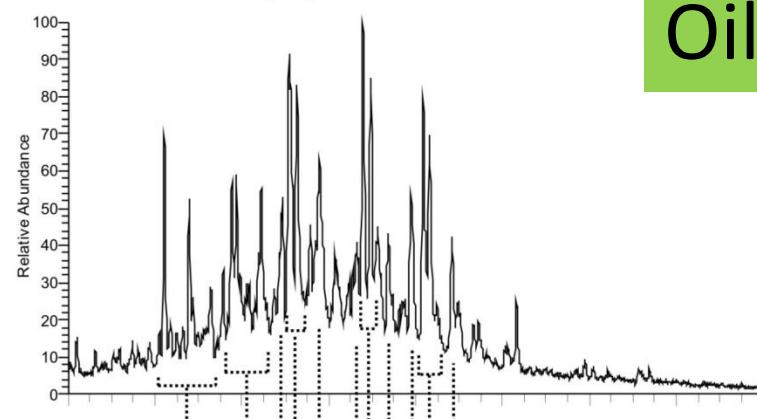


# Oil-condensate correlation - Biomarkers

Schwanenstadt-26 (Oil)

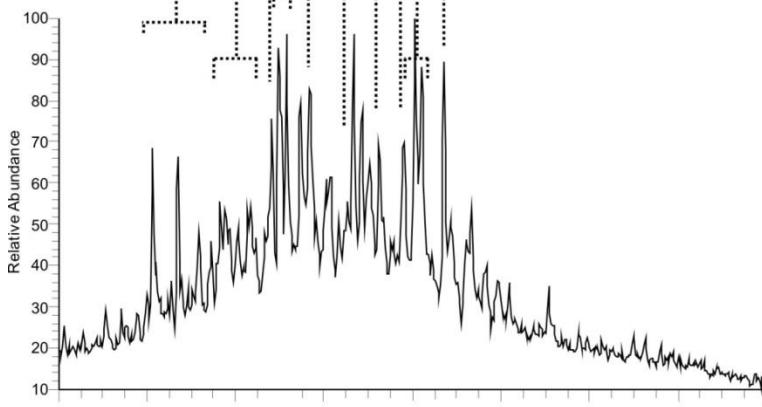


Puchkirchen-31 (Oil)

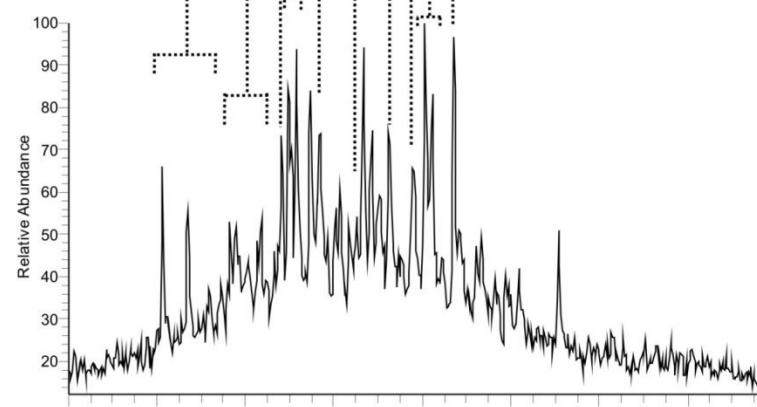


Oil

Cond.

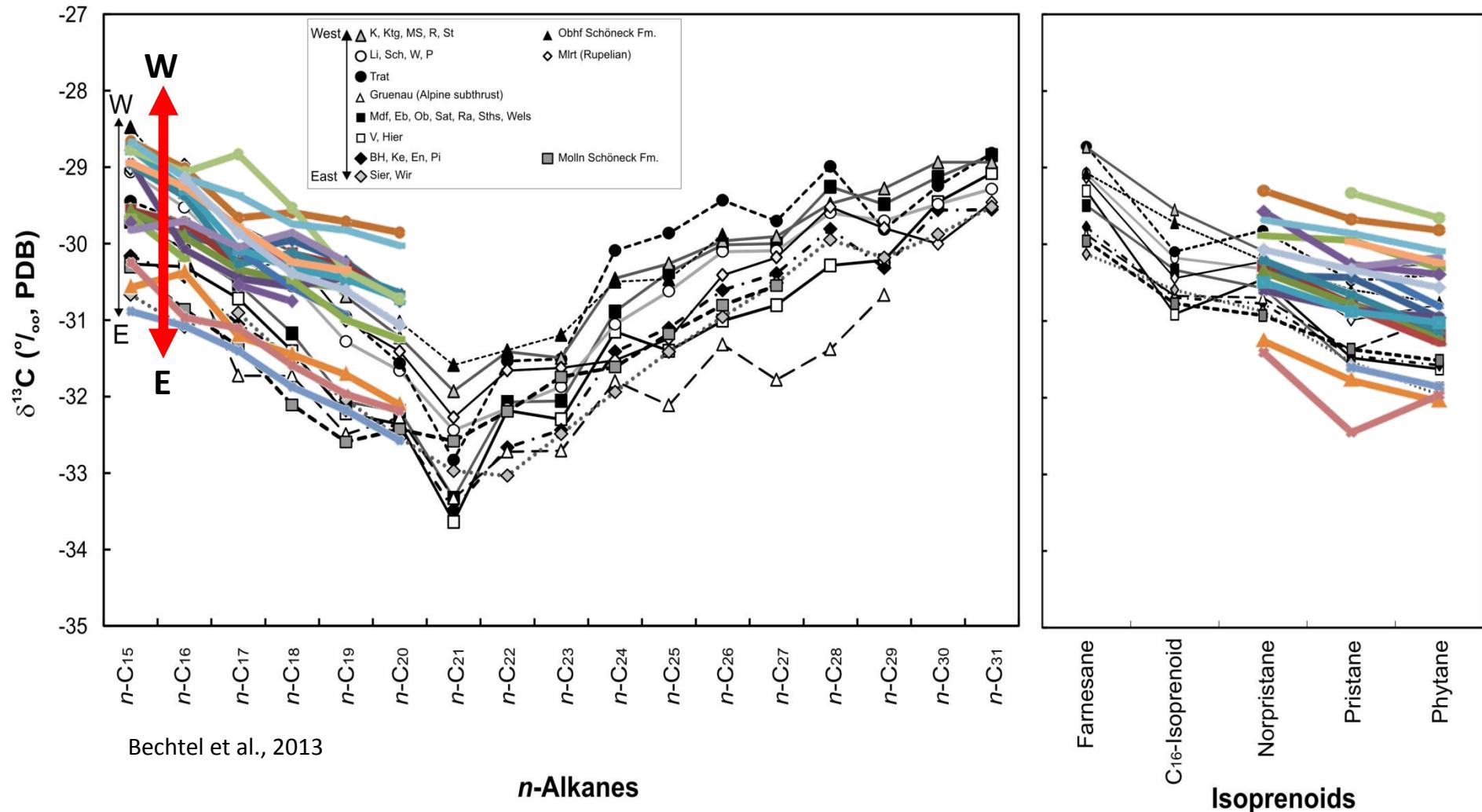


Atzbach-6 (Cond.)

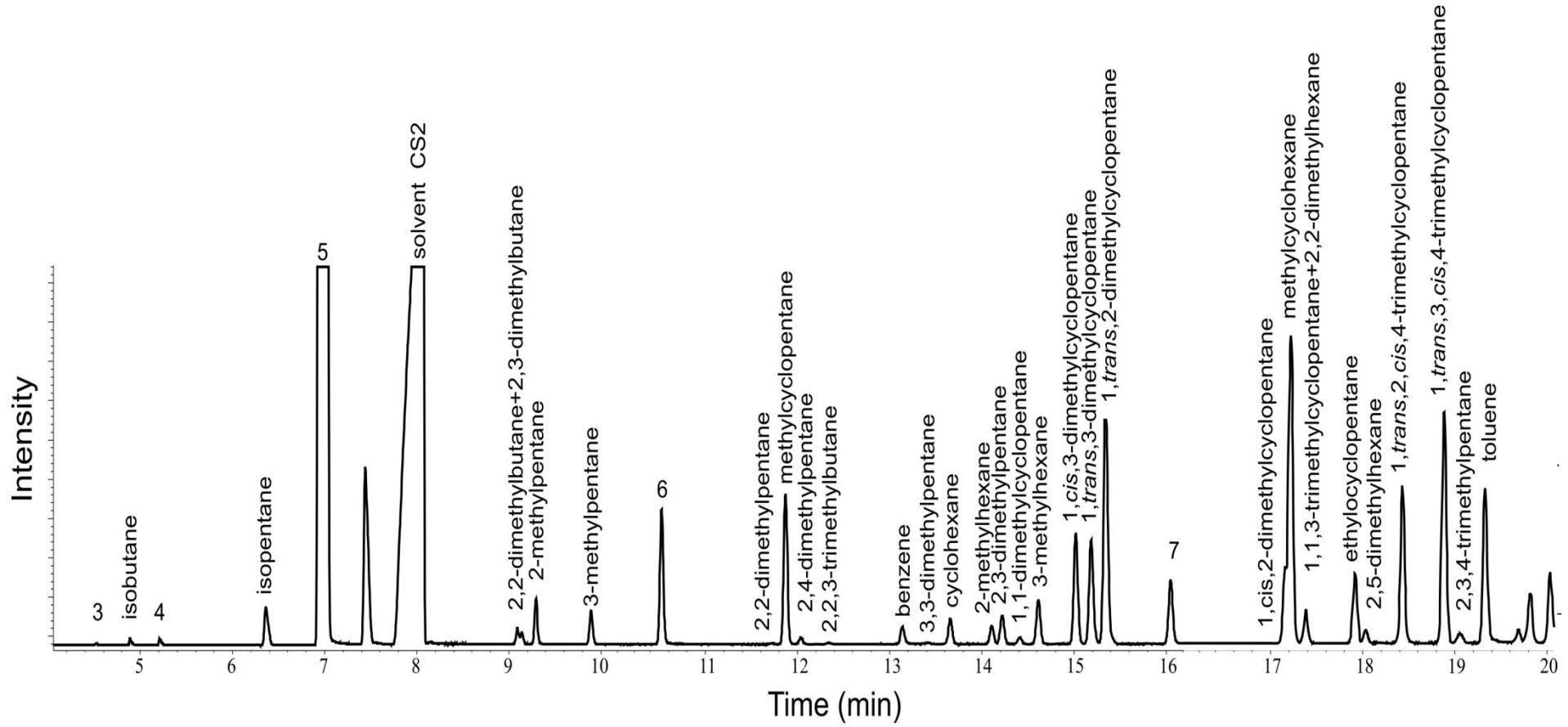


Zapf-4 (Cond.)

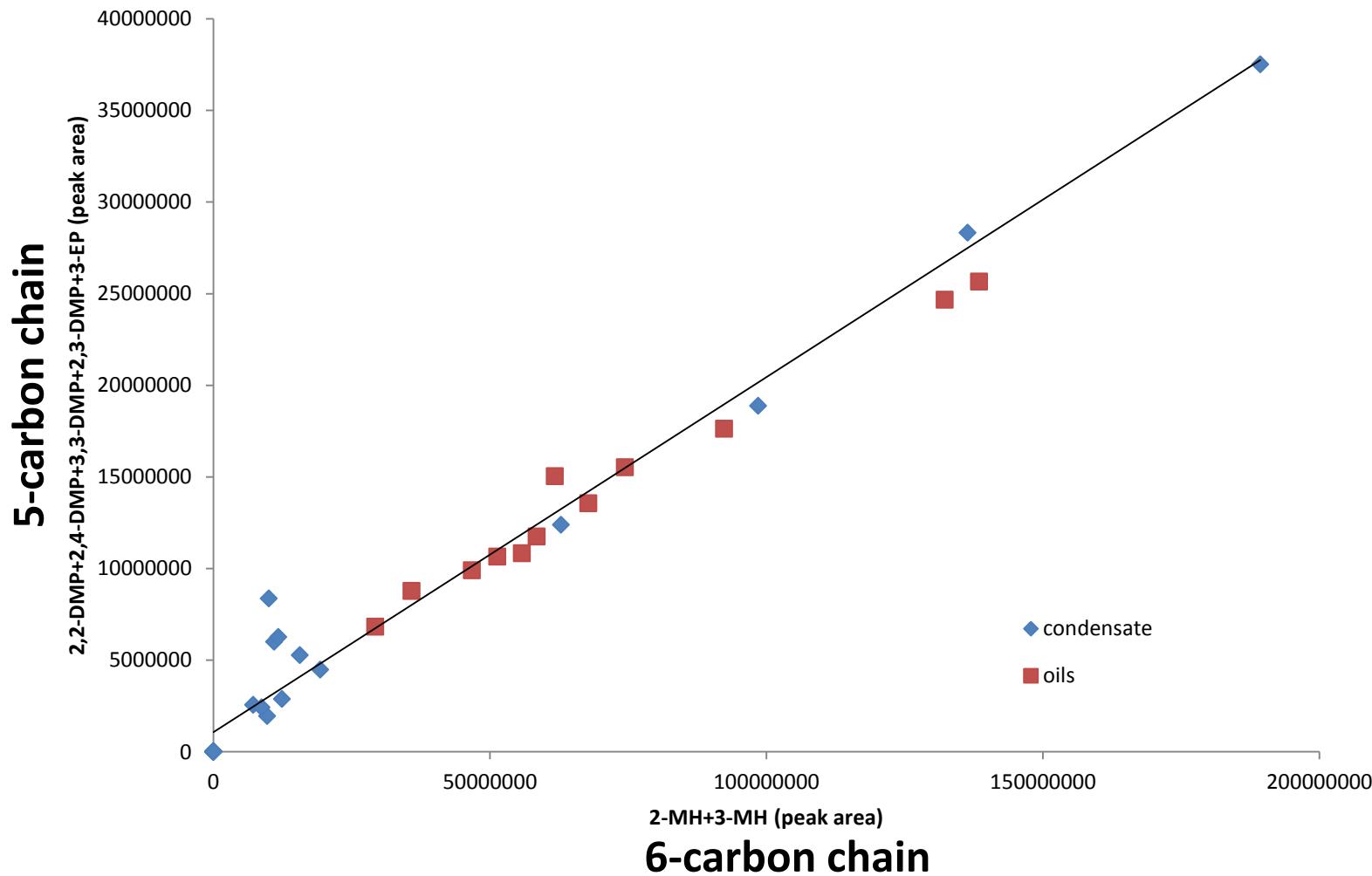
# Oil-condensate correlation – Compound specific isotope analyses



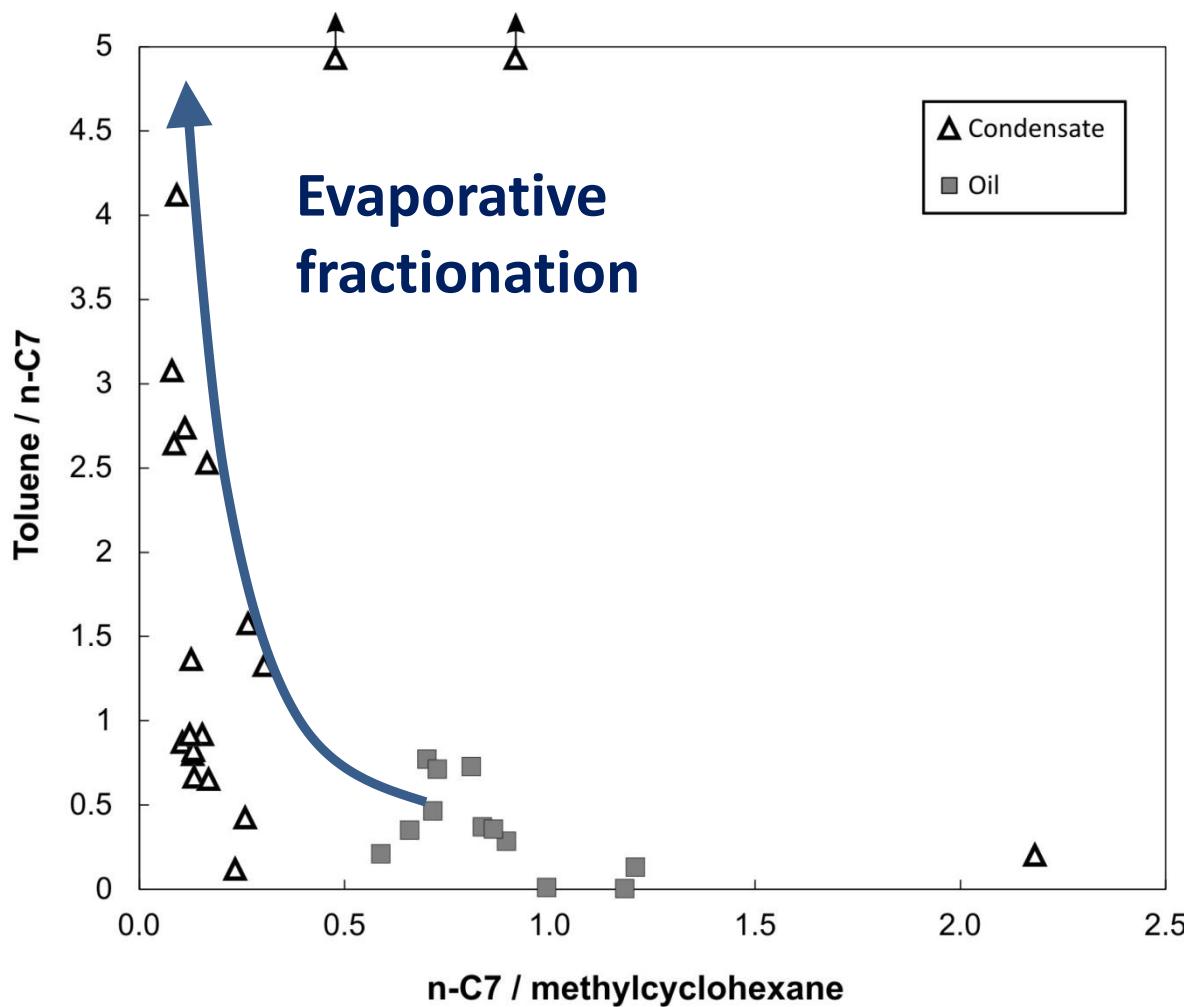
# Oil-condensate correlation – Light HC fraction



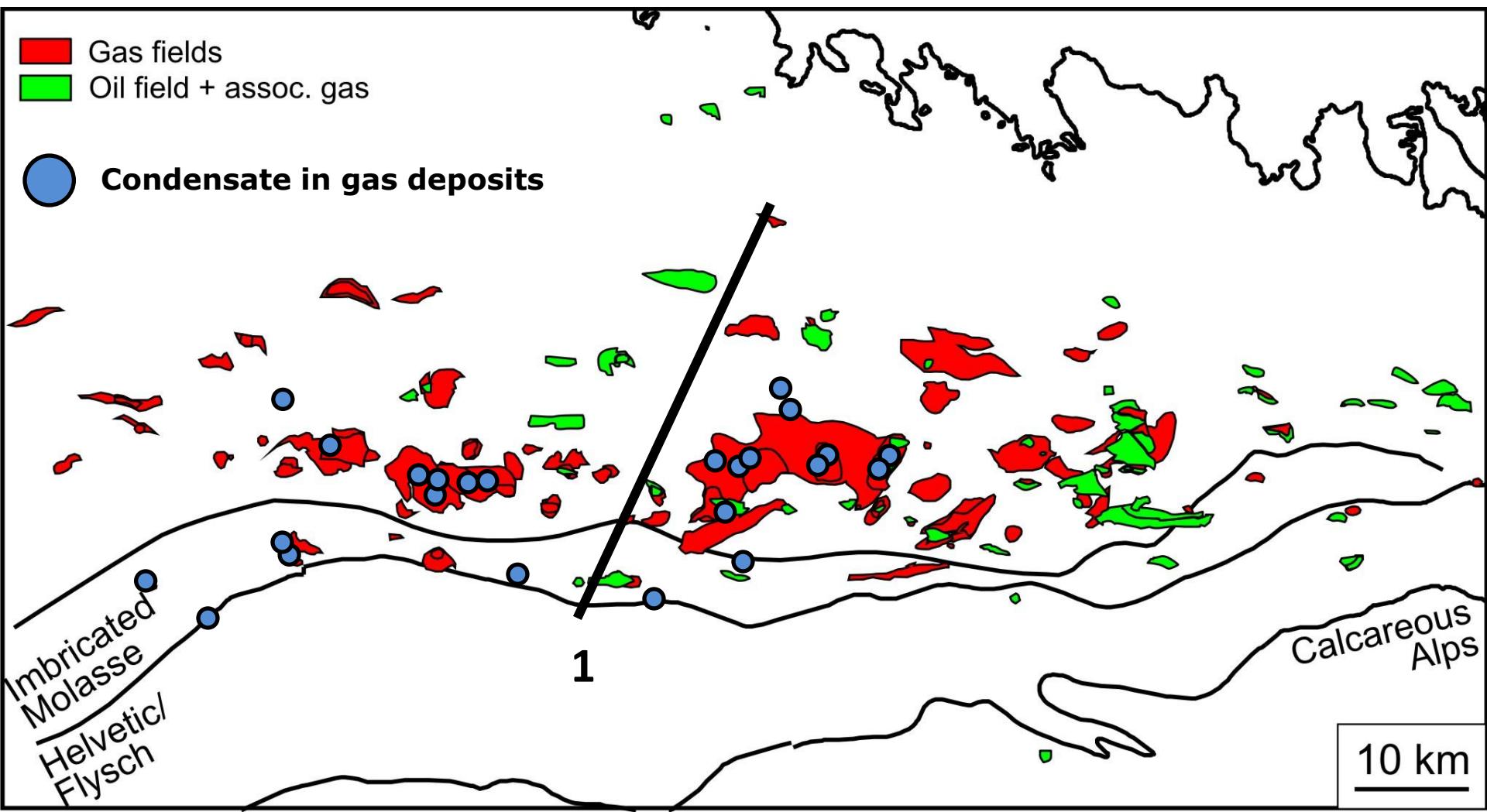
# Oil-condensate correlation – Light HC fraction



# Oil-condensate correlation – Light HC fraction



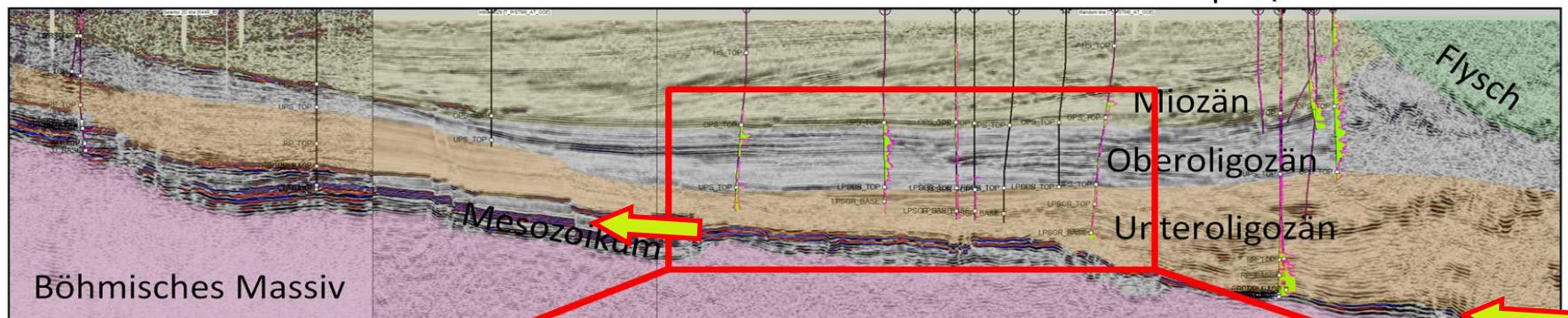
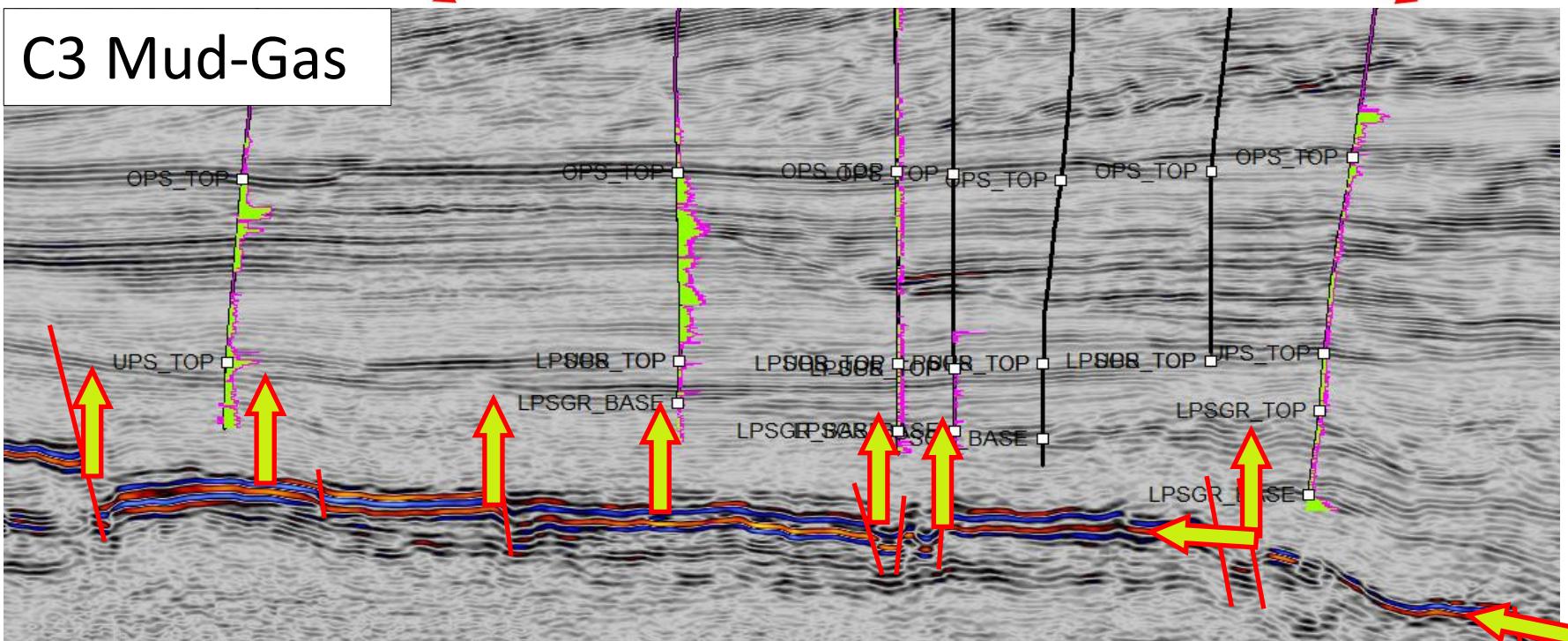
# Migration model – foreland



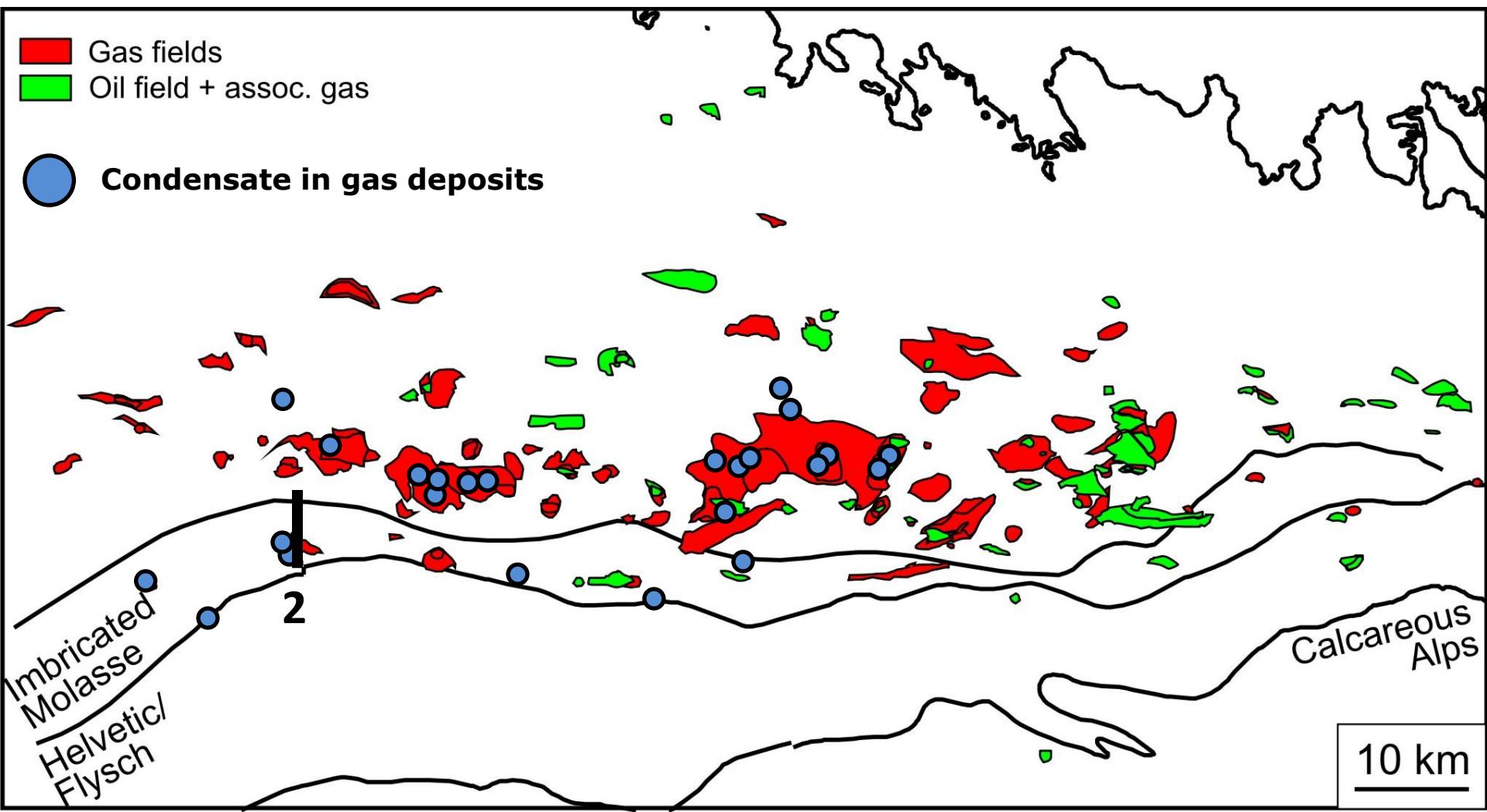
NNE

Foreland

South Slope \ Imbricates SSW

**C3 Mud-Gas**

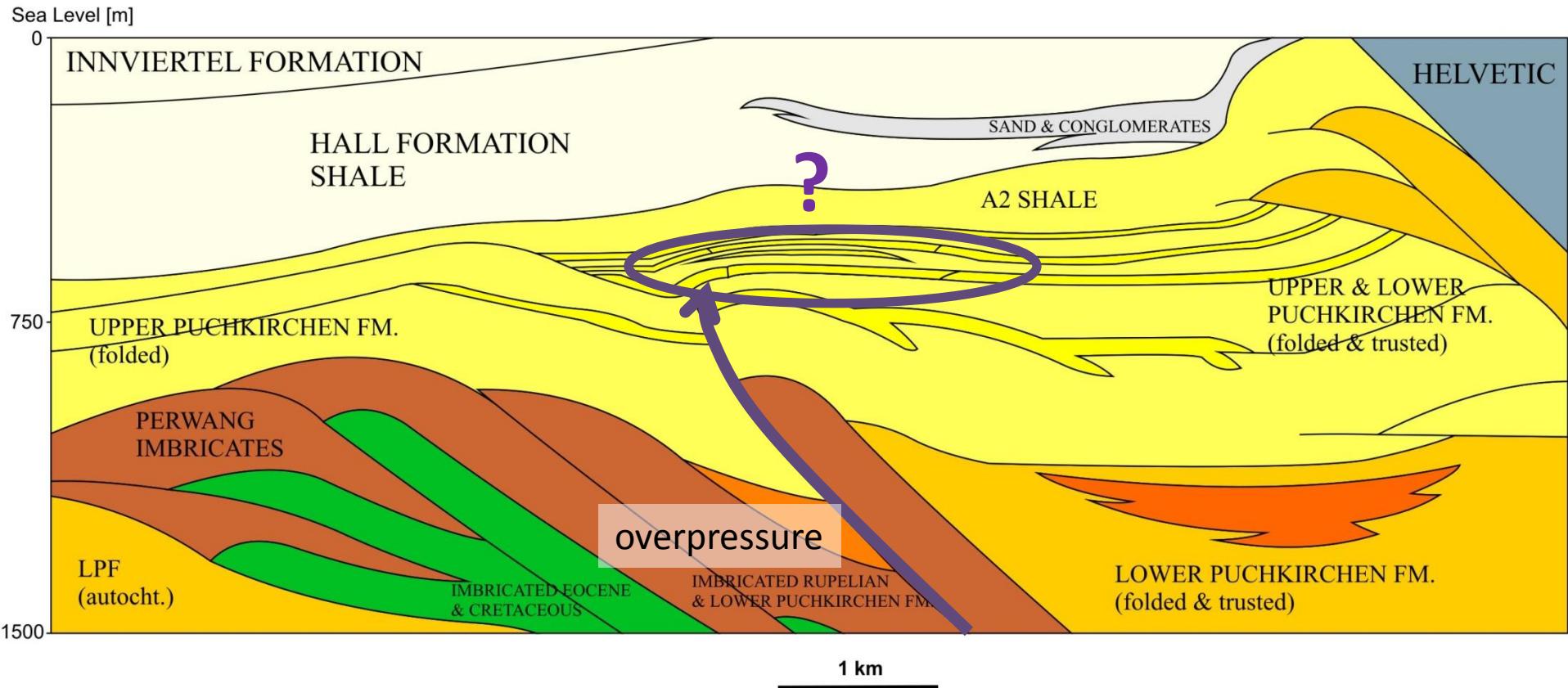
# Migration model - imbricates



# Lauterbach field cross section

N

S



# Conclusions

- HC biodegradation in oil reservoirs – isotopically light methane
- Thermogenic contribution in microbial gas deposits
- Condensate – oil – similar geochemical features
- Vertical migration from Eocene carrier beds
- Vertical migration from overpressured imbricates
- Possible undiscovered oil deposits ☺