PS Oil-Source Rock and Gas-Source Rock Correlations in the Dniepr Donets Basin (Ukraine): Preliminary Results*

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Abstract

The Dniepr Donets Basin (DDB) is a Devonian rift-structure located within the East European Craton. It is filled with Devonian syn-rift sediments and a thick Carboniferous to Mesozoic post-rift succession. The basin hosts more than 200 oil and gas fields, mainly in Carboniferous clastic rocks. Oil deposits are found in the shallow northwestern part, whereas gas deposits prevail in the deeper central and southeastern parts. Potential source rocks occur in various stratigraphic levels. Rocks with TOC contents exceeding 1 % and containing kerogen type III-II are widely distributed in Devonian to upper Visean horizons. The most prolific interval is an upper Visean black shale (Rudov Beds) with more than 5 %TOC. Highly oil-prone black shales occur in Serpukhovian intervals in the NW part of the DDB. Oil-prone Lower Serpukhovian and gas condensate-prone Middle Carboniferous coal is widespread in the S and SE part of the basin. In the 1990s, USGS investigated about 40 oil and 18 gas samples. Some biomarker and stable isotope parameters are available from the USGS database. In the present contribution, we use these data together with data from 13 oil and condensate samples, which were determined within the frame of the present study and compare them to published data measured on rock extracts. Pristane/phytane (Pr/Ph) ratios of accumulated oils and condensates vary significantly between 0.7 and 3.9. Typically, samples with low Pr/Ph ratios are characterized by light C-isotropy. The dibenzothiophene/phenanthrene (DBT/Ph) ratio is low (<1) in all studied samples. Low Pr/Ph ratios (<1.3) are typically found in extracts from Devonian rocks and from Rudov Beds. Higher Pr/Ph ratios are derived from Serpukhovian rocks. Pr/Ph ratios from other Upper Visean rocks range from 1.1 to 2.3. Extracts from Devonian rocks are characterized by lighter carbon isotopic composition than extracts from Visean and Serpukhovian rocks. Unfortunately, no data for Rudov Beds are available yet. With the exception of Lower Visean carbonate rocks, DBT/Ph ratios of potential source rocks are generally low. This suggests that different source rocks contributed to the accumulated oil and condensate. Isotopic compositions of methane and ethane from gas samples in the DDB suggest generation from source rocks containing a type II kerogen with varying maturity (0.6 – 1.5 %Rr). Based on isotopic composition, gas from the southeastern part of the basin may be derived from coal-bearing successions.

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1. Introduction

The Dniepr Donets Basin (DDB) is filled with Devonian syn-rift sediments and a thick Carboniferous to Mesozoic post-rift succession. The DDB hosts more than 200 oil and gas fields (**Fig. 1**). Oil deposits are found in the shallow NW part, whereas gas deposits prevail in the deeper central and SE parts.

In the present contribution we use biomarker and isotopic data from 13 oil and condensate samples, which were determined within the frame of the present study, and compare them with published data measured on oils and rock extracts.

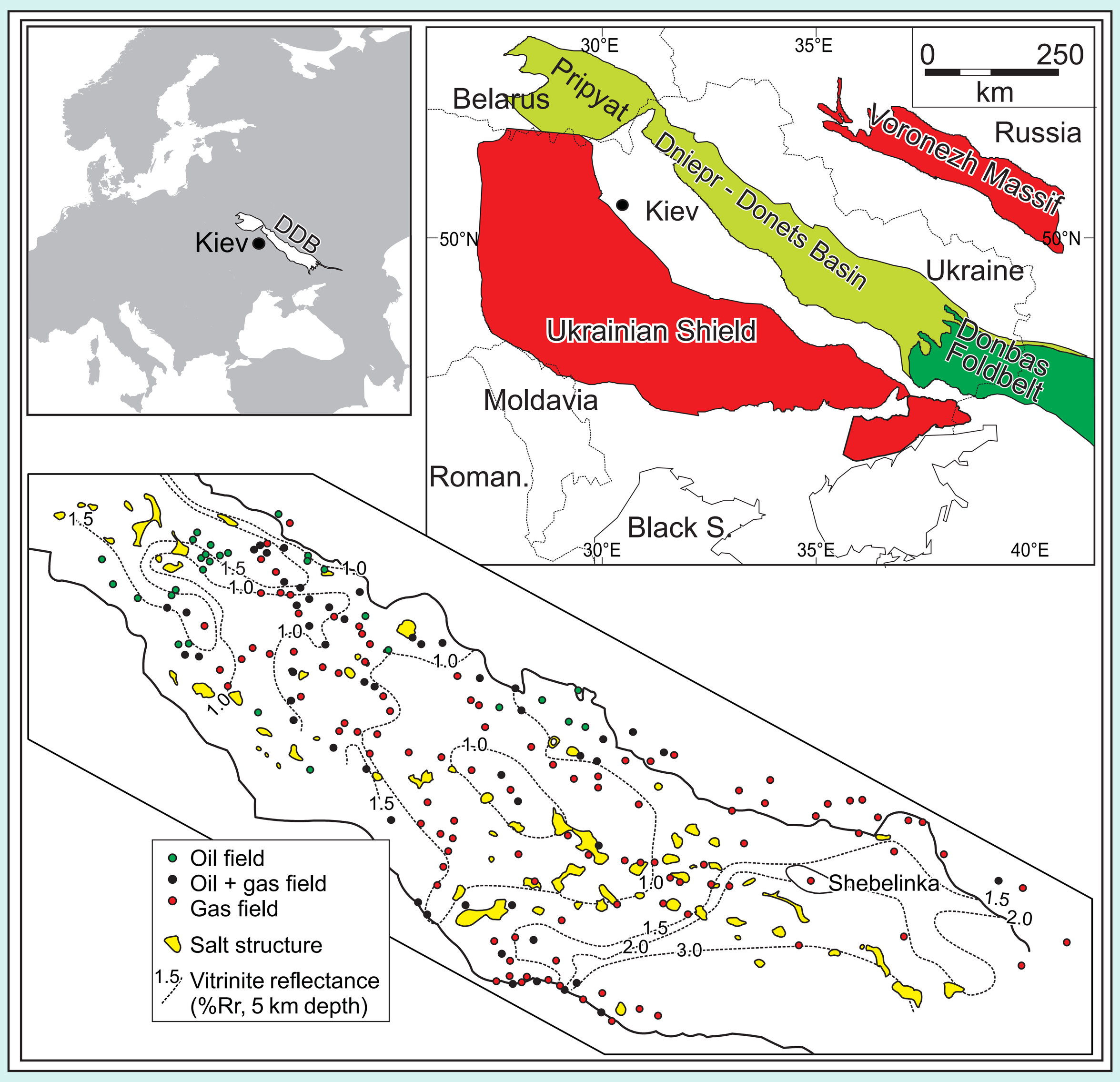

***Fig. 1.** Regional setting and overview of oil and gas fields in the northwestern and central Dniepr-Donets-Basin.*

2. Geological setting

Middle Devonian terrestrial and shallow-marine pre-rift deposits represent the oldest strata in the DDB (**Fig. 2**). Late Devonian syn-rift sediments reach a maximum thickness of ~4 km (**Kabyshev et al., 1998**).

The Carboniferous post-rift succession with a maximum thickness >10 km is represented by continental deposits in the NW DDB and by cyclic successions of siliciclastic and minor carbonate rocks deposited in fluvial, shallow-marine and lagoonal environments elsewhere. A basin-wide Lower Visean carbonate platform was the result of a major transgression from the SE (**Dvorjanin et al., 1996**).

Black shales up to 70 m thick ("Rudov Beds", V-23) overlie the Lower Visean carbonate platform. Rudov Beds are considered as one of the main hydrocarbon sources in the DDB.

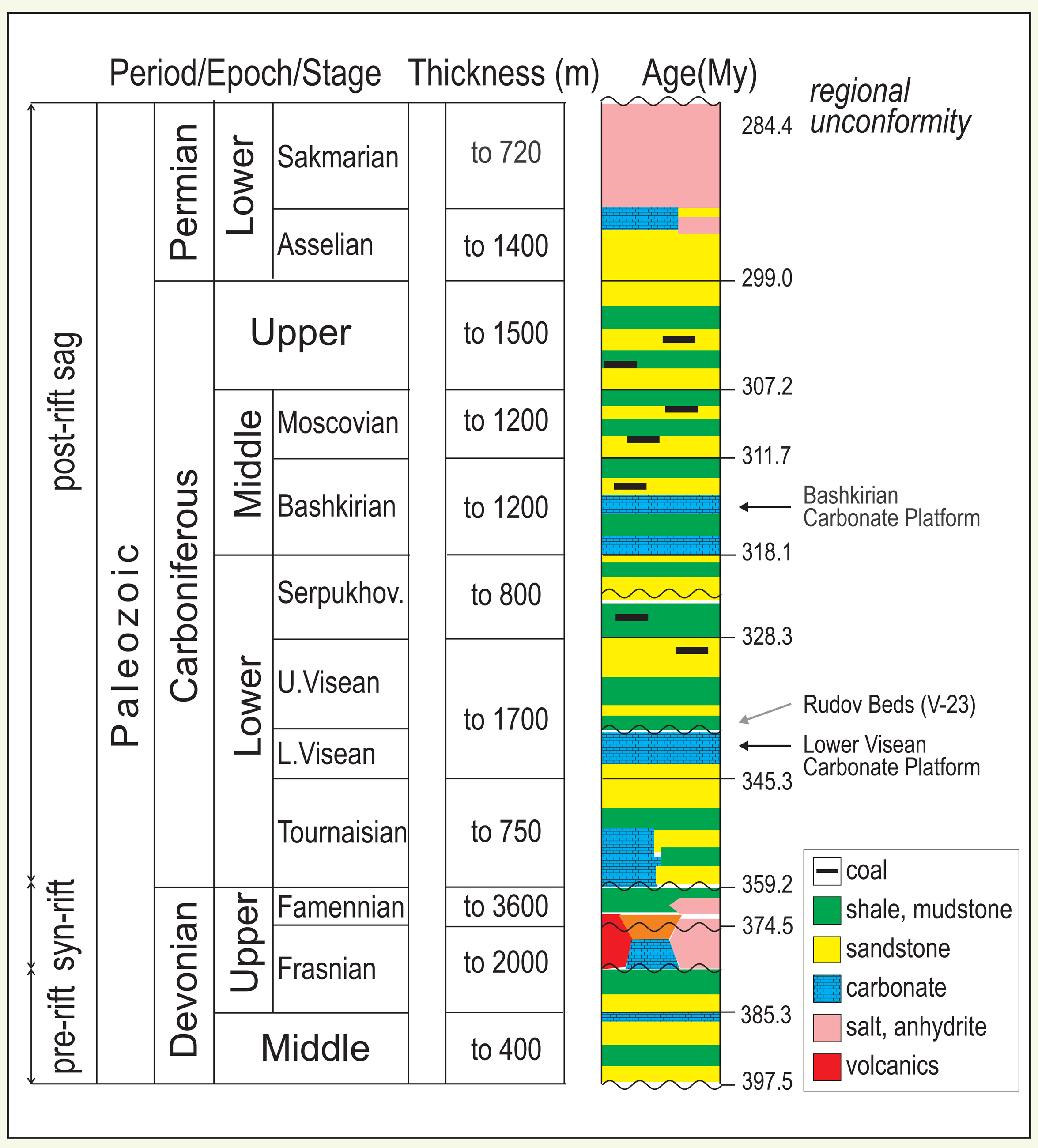

***Fig. 2.** Chrono- and Lithostratigraphy of the DDB (after **Shymanovskyy et al., 2004**). Age data follow **Gradstein et al. (2004)**.*

3. Methods

The fractions of the hexane-soluble organic matter from oils and rock extracts were separated into polar compounds, saturated hydrocarbons and aromatic hydrocarbons using a Köhnen-Willsch MPLC instrument (**Radke et al., 1980**). Condensates were diluted in n-pentane and subjected to the gas-chromatographic analyses (GC-MS) without further pre-treatment. Biomarker analysis followed established procedures (e.g. **Bechtel et al., 2012**). Stable isotope ratios are reported in delta notation ($\delta^{13}C$) relative to the V-PDB standard.

5. Conclusions

The data compilation partly supports earlier concepts of **Ruble (1996)** and **Ruble et al. (1997)** and shows that there are at least two oil families, isotopically heavy oil with high Pr/Ph ratios and isotopically light oil with low Pr/Ph ratios.

Oil-source correlations based on biomarker and isotope data from rock extracts (**Sachsenhofer et al., 2007 & 2014; Sachsenhofer et al., 2010**) suggest that the isotopically light oil with low Pr/Ph ratios was most probably generated from Rudov Beds (V-23).

Ruble (1996) and **Ruble et al. (1997)** argued for a Devonian source, which is contradicted by low TOC contents of Devonian rocks in areas with oil accumulations.

A minor contribution of Serpukhovian oil-prone rocks to the accumulated isotopically light oil with low Pr/Ph ratios cannot be excluded.

Various Carboniferous source rock horizons may have generated the isotopically heavy oil with high Pr/Ph ratios.

4. Results and Discussion

Pr/Ph ratios of accumulated oils and condensates vary significantly between 0.7 and 3.9. DBT/P is remarkably low for Upper Visean Rudov Beds (**Fig. 3**).

Typically, samples with low Pr/Ph ratios are characterized by light C-isotopy (**Fig.4**).

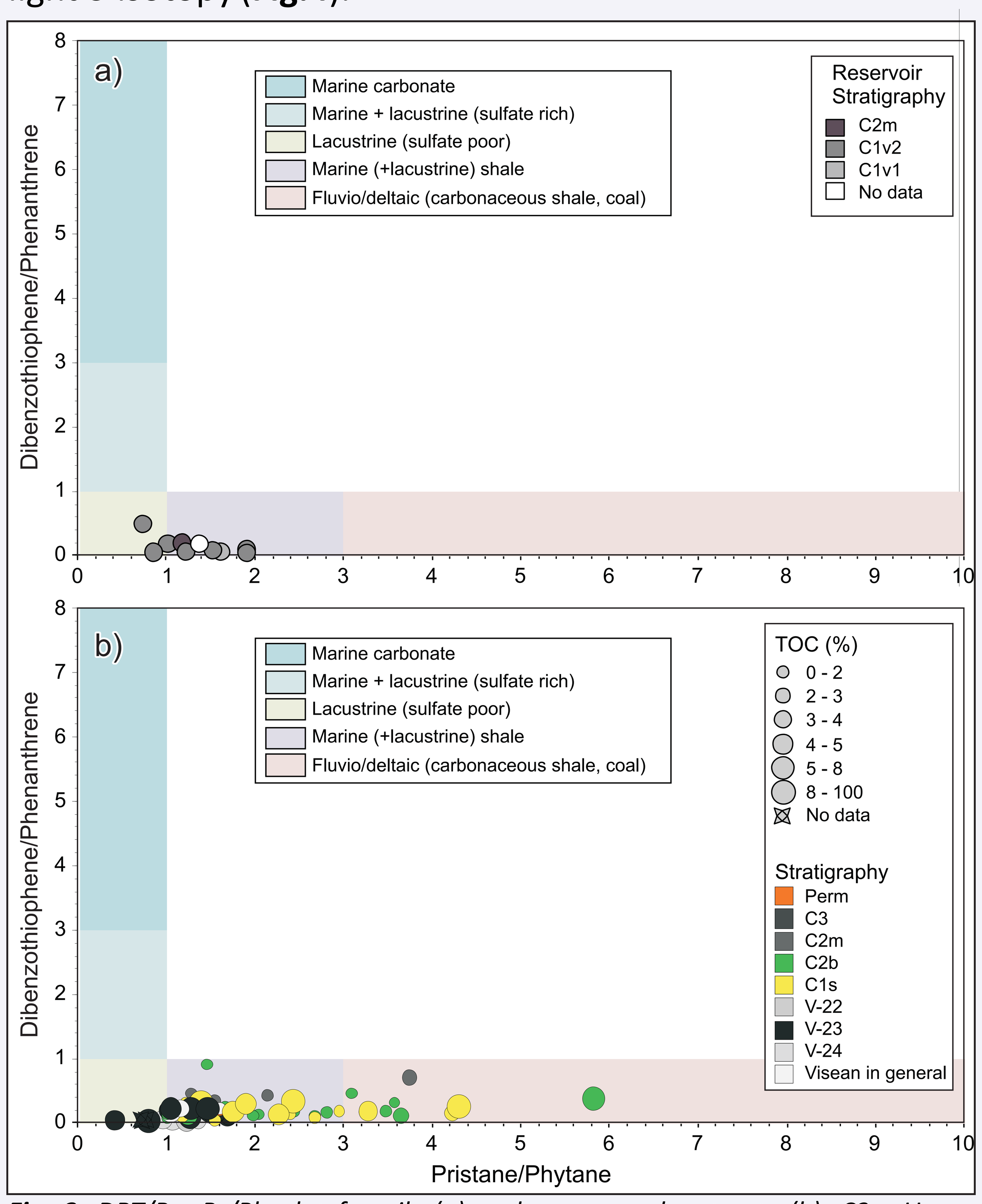

***Fig. 3.** DBT/P - Pr/Ph plot for oils (a) and source rock extracts (b). C3 - Upper Carboniferous; C2m - Moshkovian; C2b - Bashkirian; C1s - Serpukhovian; V-23 - Rudov Beds; V-16-25 - other Visean horizons*

Pr/n-C17 to Ph/n-C18 varies strongly for different horizons (**Fig. 5**).

Isotopic composition of saturated and aromatic compounds show a distinct pattern for Rudov Beds in comparison to other organic rich Visean horizons (**Fig. 6**).

This is also reflected by the isotopic variation in oils/condensates.

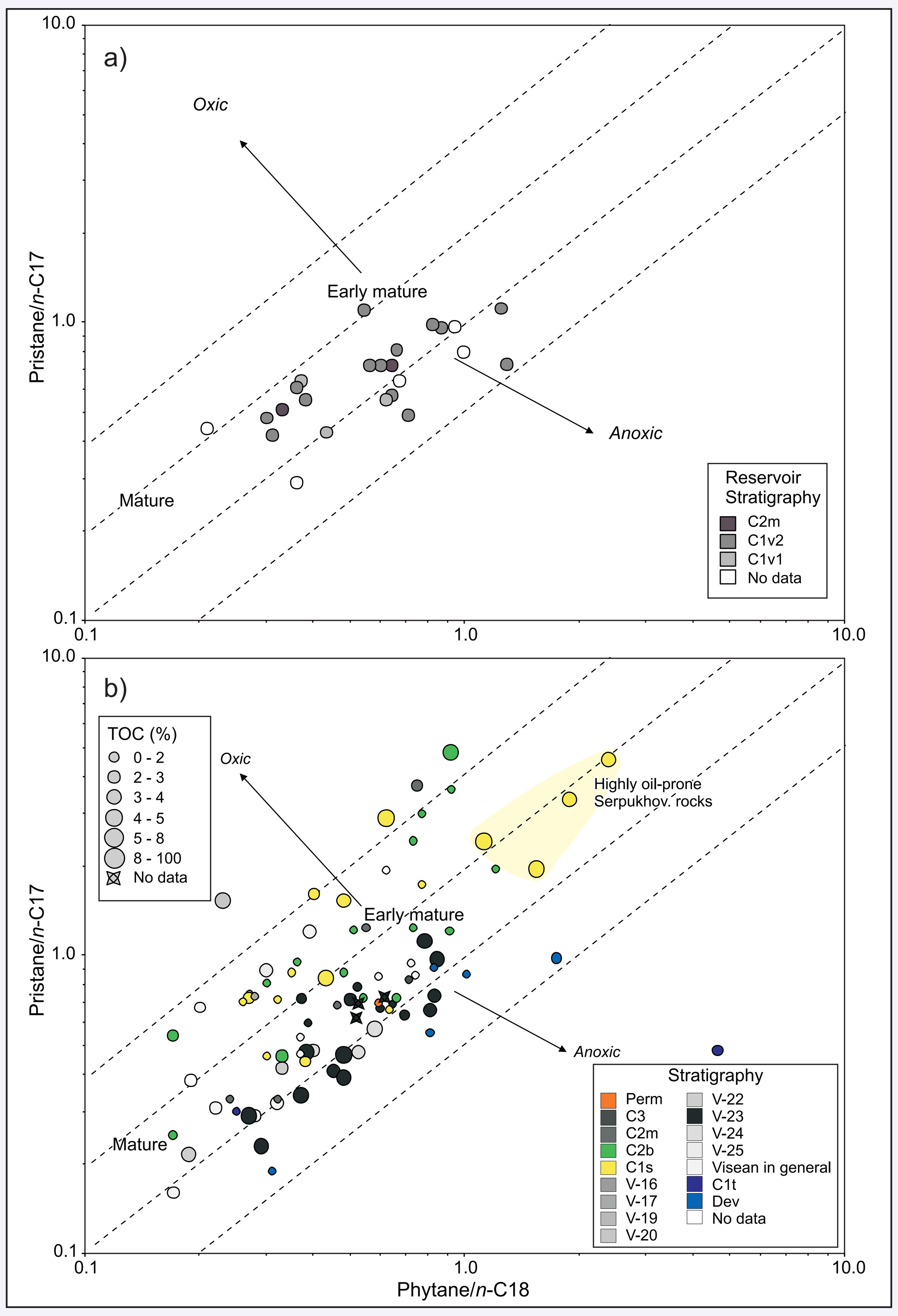

***Fig. 5.** Pr/n-C17 - Ph/n-C18 plot for oils/condensates (a) and source rock extracts (b). Colors indicate source/reservoir stratigraphy, point size of rock extracts indicates TOC content. Abbrev. as described in Fig. 3 & 4.*

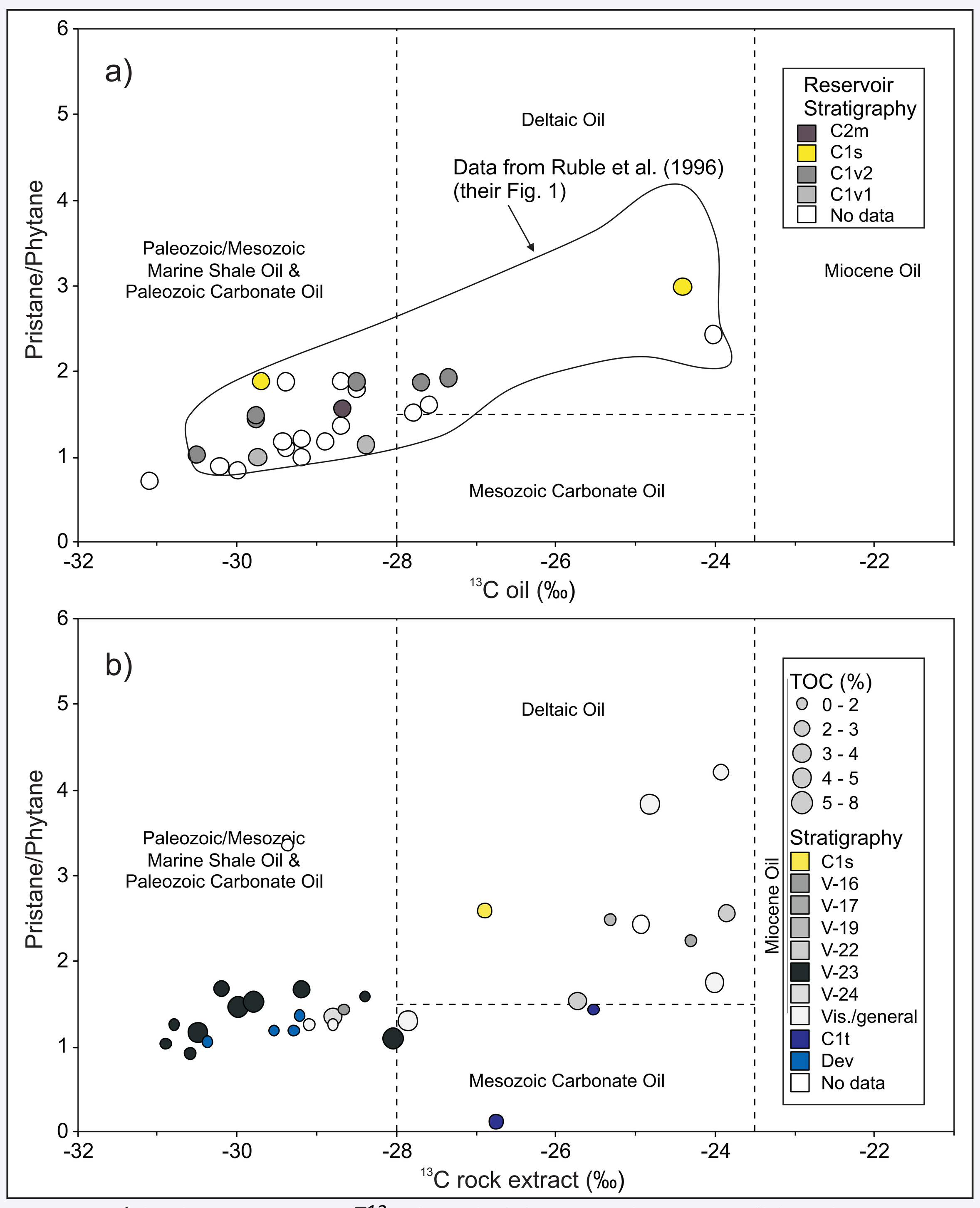

***Fig. 4.** Pr/Ph plotted against $\delta^{13}C$ for oils (a) and rock extracts (b). Colors indicate source/reservoir stratigraphy, point size of rock extracts indicates TOC content. C1t - Turonian; Dev - Devonian; other abbrev. as described in Fig. 3.*

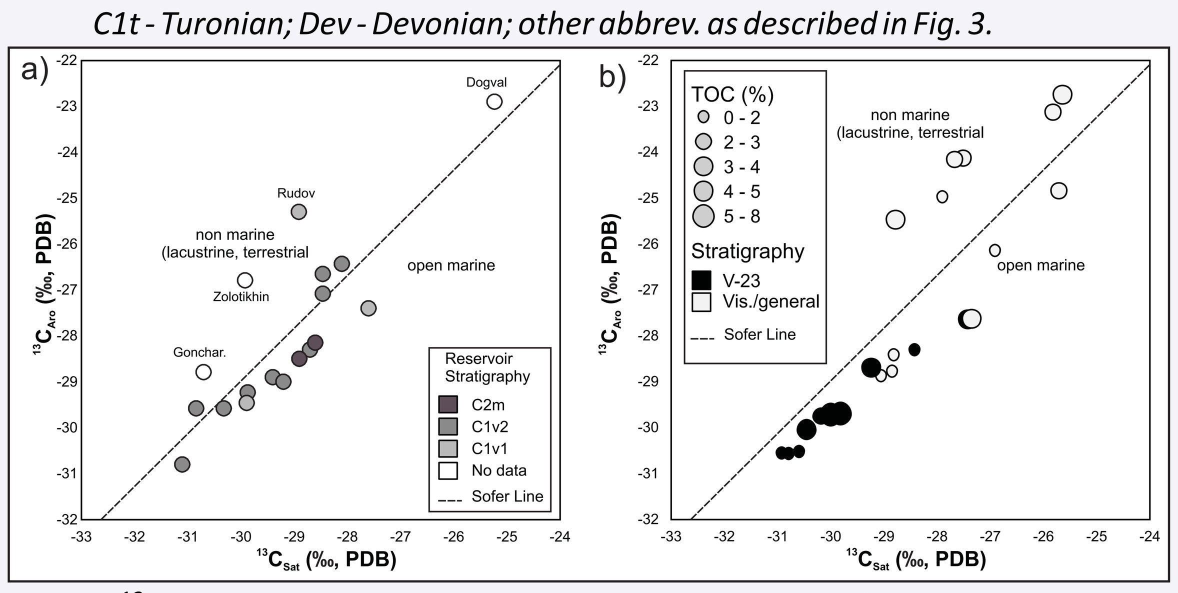

***Fig. 6.** $\delta^{13}C$ of saturated against aromatic compounds for oils/condensates and rock extracts after **Sofer (1984)**. C1v1 - Lower Visean; C1v2 - Upper Visean; other abbrev. as described in Fig. 4 . Point size indicates TOC content of rocks.*

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