Depth of Oil Window of the Eastern Part of the Precaspian Basin (Kazakhstan)*

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Abstract

The Precaspian Basin is the main oil province in Kazakhstan, where there are such giant fields as Tengiz, Karachaganak, Astrakhan, and Kashagan. Previous works have identified source rocks associated mainly with the sub-salt complex. However, the issue of such parameters as the depth of the oil window remains unresolved, because the geothermal gradient is low and the studied source rocks have a low maturity. By the study of the organic matter in these sediments, we wanted to determine the depth range of oil window for essential source rocks.

Procedures

The samples have been analyzed by petrography (macerals and vitrinite reflectance), geochemistry (Rock-Eval and extracts). The burial simulation and the paleotemperature estimation were calculated by the Petromod 1D software (IES Gmbh, Germany) for seven wells of different tectonic zones.

Results

This area is composed of three parts from Devonian to late Carboniferous: the Precaspian Basin subdivided into a basin (claystones, mudstones, and calciturbidites) and a platform (limestone and storm sandstones), and the Pre-Uralian Basin (turbidite sandstones) and the depth lies between 1700 m and 5450 m.

For the studied sector the values of the Ro are low and varies from 0.4 to 0.7 and Tmax lies between 420 and 445°C. The majority of the saturated hydrocarbon chromatograms obtained from the rocks representative of the various facies confirm the results obtained on the solid residue. The chromatograms are typical of not very mature organic matters. The Precaspian and Preouralian basins have, like specificities, a weak heat gradient and in their geological history the burial dominated compared to the uplift.

A thermal model constructed using Petromod software in the region was able to provide a good calibration between observed and calculated vitrinite reflectance and maturity zones. The VR-depth diagram exhibits three types of gradients: the lowest in the western basin (Figure 1a) and platform of Precaspian Basin, the middle in the Pre-Uralian Basin and the highest in the eastern Suture zone trusted by the Ural nappes (Figure 1b).

The model indicated that the depth of the beginning of the oil window is deep because the thermal gradient is lower than 25 C/km. We can observe this gradient decreasing from east to west because of the high thermal conductivity of the covering evaporites (Figure 2)

In the early Permian rocks, the maturity increases from the west in the Precaspian Basin to the east in the Pre-Uralian Basin and the suture zone. The Carboniferous rocks in the Precaspian Basin appear to have a lower maturity than early Permian rocks of the Pre-Uralian Basin.

The simulation of the heat flow was calibrated by Vitrinite reflectance with different kinetics according to the type of organic matter - Vandenbroucke et al., (1999) model were chosen for the type III (Brent) and for the type II (KCF).

Plots of R_r and T_{max} (Figure 3) show little indication of increasing maturity with depth, except for deep samples from the suture zone.

Previous study of bitumen in the samples of Palaeozoic series showed that the low value of the heat gradient can be compensated by the geological duration during which source rock undergoes the transformation. In the sector studied the phase of generation of oil can correspond to the level of evaluation, corresponding to value 0.5% of Ro and even 0.4% for the algal type or mixed OM II/III.

Conclusions

For the studied formations, the major part of hydrocarbons were generated from the maximal phase of burial. We can distinguish four zones in which the depths of the beginning and end of the oil window are different: the western zone (basin) from 4-4.5 km to 7-9 km, the zone of slope and border from 3-3.7 km to 4.5-5 km, the zone of Preuralian Basin from 2.8-3.3 to 4.5-5 km, and the eastern zone under the thrust of Ural (Izembet) from 2-2.8 to 3.5-4 km.

Reference

Vandenbroucke, M., F. Behar, and J.L. Rudkiewicz, 1999, Kinetic modeling of petroleum formation and cracking; implications from the high pressure/high temperature Elgin Field (UK, North Sea): Organic Geochemistry, v. 30/9, p. 1105-1125.

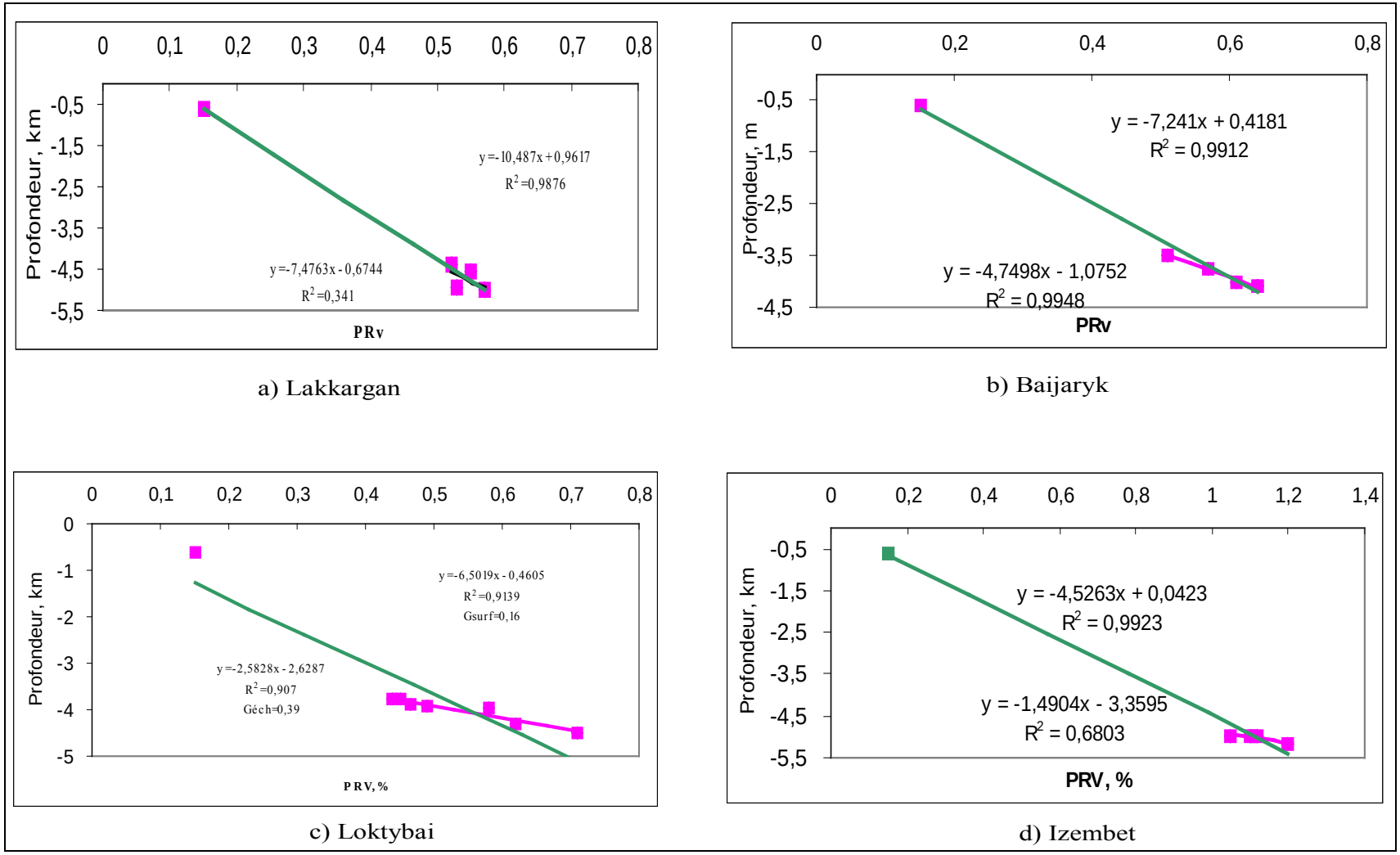

Figure 1. Diagrams Ro function of depth for the different tectonic zones. The trend pink line - the gradient from the measured Ro of samples (Géch), the green trend line - the gradients of calculated Ro (Gsurf).

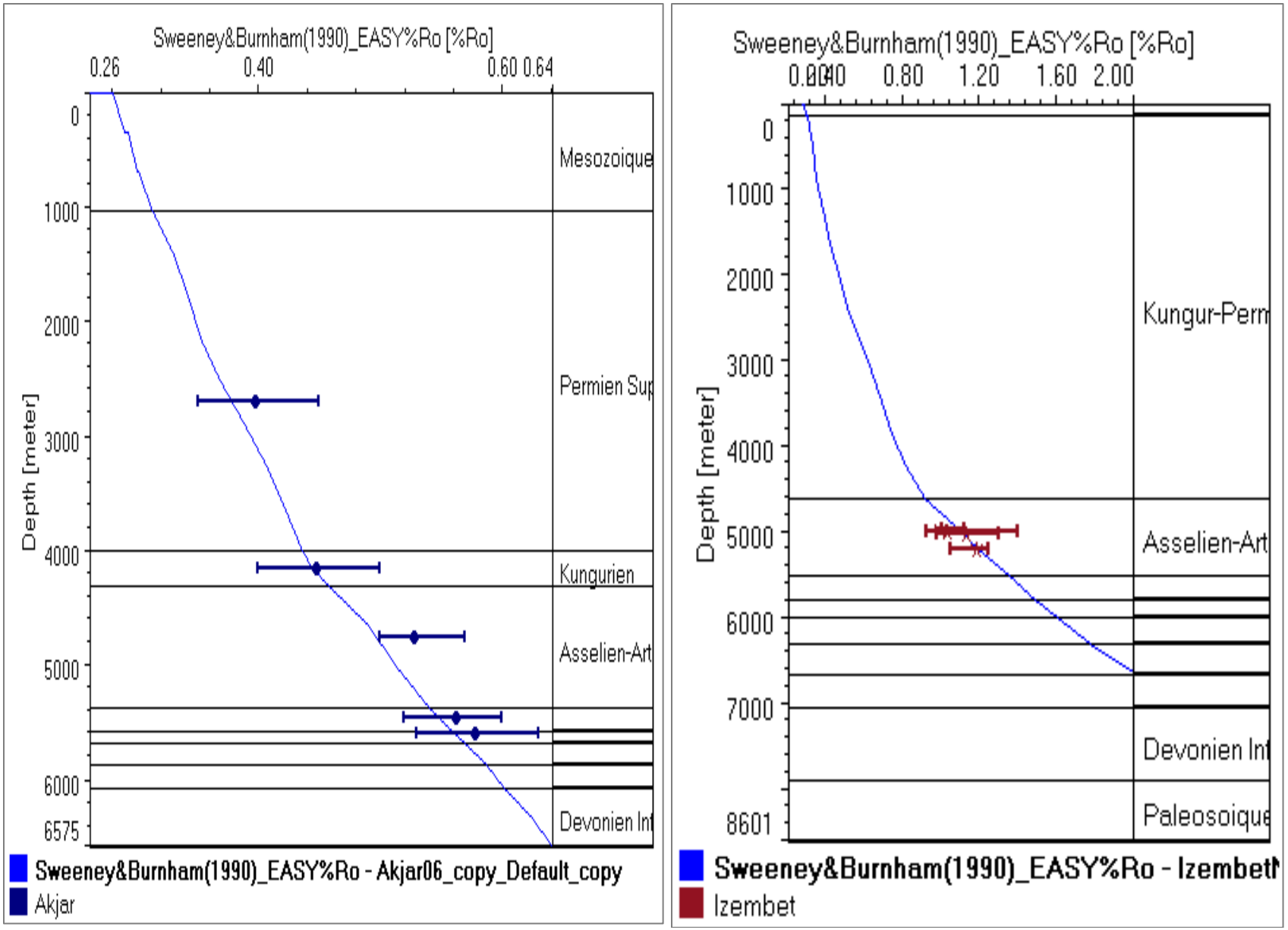

Figure 2. Calibration of thermal history by vitrinite reflectance in a) Akjar and b) Izembet wells.

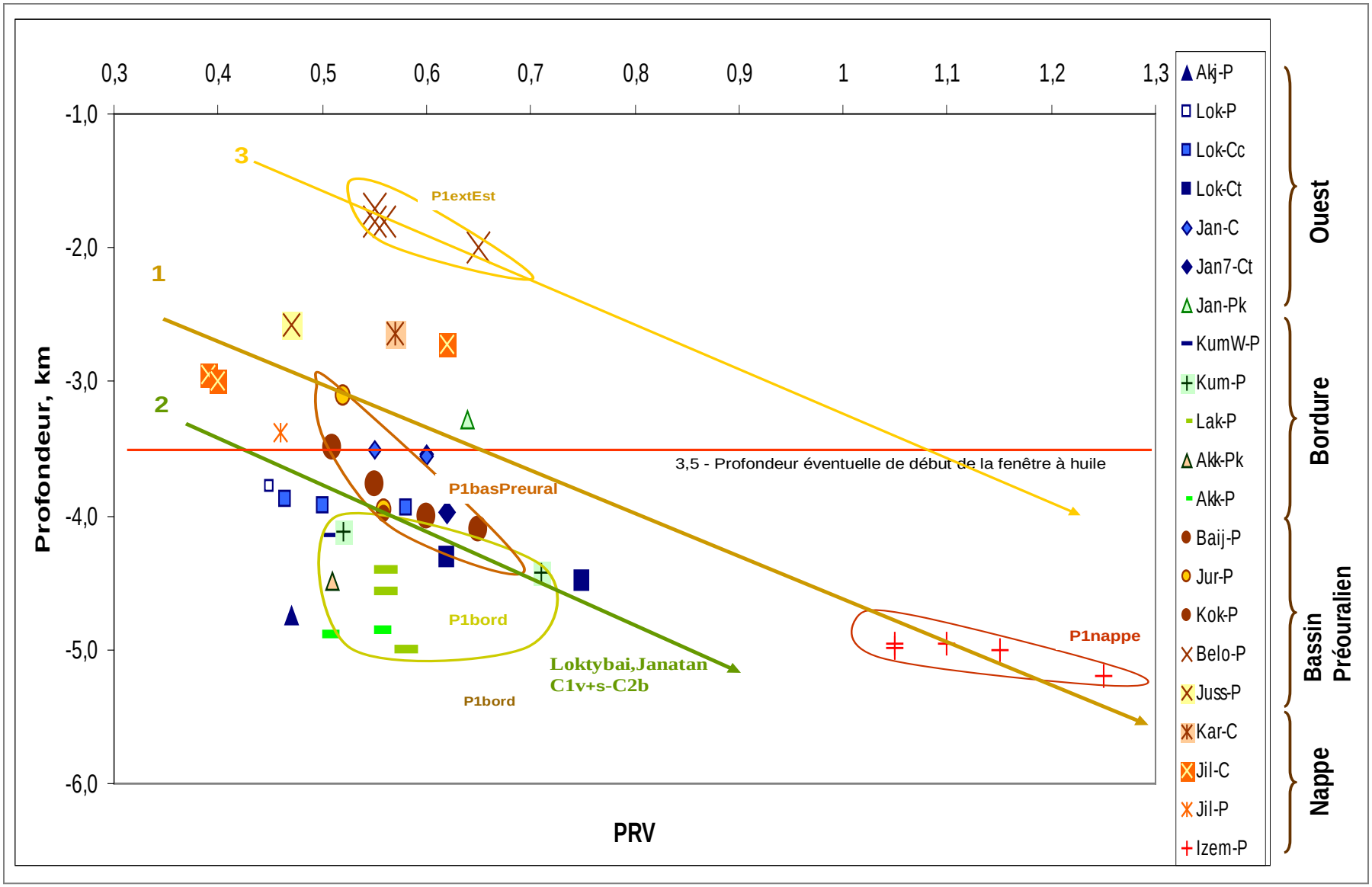

Figure 3. Diagram Depth function of Ro. Stratigraphy: C - Carboniferous; C1V - Visean, C2 – Bashkirian+Moscovian; P – Early Permian; Ps - Sakmarian; P1k - Kungurian. Lithology: Cc - calciturbidites of Carboniferous; Ct - terrigenous turbiditic series of Lower-middle Visean; Mc - micrite. Localities: Akj - Akjar-Kenkiyak; Akk - Akkuduk; Baij - Baijaryk; Belog - Belogorskaya; Izem - Izembet; Jan - Janatan; Jil - Jilansayd; Jur - Jurun; Juss - Jussa; Karn - Karnak Kokt - Koktobe; Kums - Kumsai; Lak - Lakkargan; Lok - Loktybai; W.Kums - Kumsai West. In the legend the wells are grouped by areas: ‘West’, ‘Border', ‘Préouralien Basin’, 'Nappe'.