PALEOZOIC PETROLEUM SYSTEMS OF THE WEST SIBERIAN BASIN - WHAT IS THE EVIDENCE?

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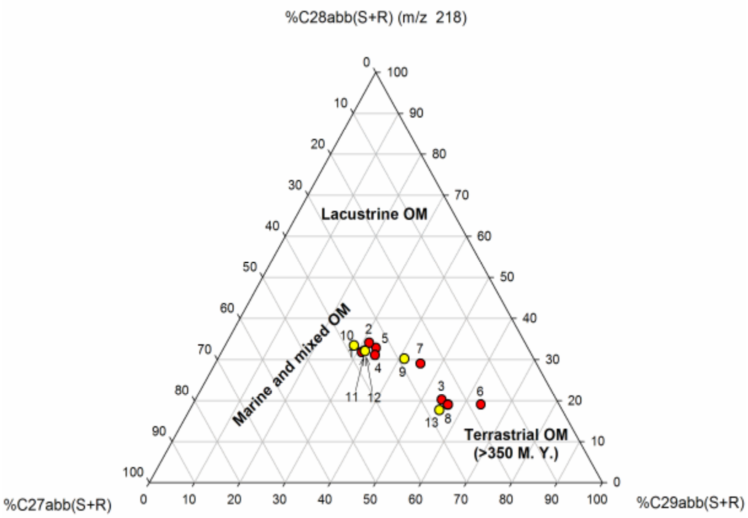
Mesozoic petroleum systems in the West Siberian Basin have been studied extensively and are relatively well understood (Goncharov 1988, Kontorovich et al. 1996, Rudkevich et al. 1988, Peters et al. 1994). The two main source systems are the Upper Jurassic marine Bazhenov suite (J_3) and the Lower-Middle Jurassic more terrigenously influenced Togur/Tyumen suites (J_1-J_2). Most of the oils known to be generated by these sources are produced from Mesozoic reservoirs. However, there is also production from Paleozoic strata. The petroleum systems related to these latter reservoirs are much less understood, in particular with respect to source, and form the basis of this study. The oils studied here are from Paleozoic reservoirs located in the western part of the basin around Uray and the south-eastern area around Tomsk.



Samples

South-eastern area (Red)
1. Eley-Igayskoe, 2, 3808 m
2. Kalinovoe, 6, 2970-2980 m
3. Maloichskoe, 2, 2842-2849 m
4. Nizhne-Tabaganskoe, 4, 3068-3080 m
5. Yzhno-Tabaganskoe, 130, 2981-3012 m
6. Severo-Ostaninskoe, 7, 2794-2810 m
7. Urmanskoe, 2, 3091-3103 m
8. Verhnetarskoe, 3, 2692-2704 m

Western area (Yellow)
9. Rogozhnikovskoe, 729, 2568-2607 m
10. Yahlinskoe, 851, 4025-4070 m
11. Palyanovskoe, 51, 2219-2422 m
12. Ubinskoe, 328, 1879-1913 m
13. Hanti-Mansiyskoe, 5, 3118-3152 m

Figure 1. Distribution of αββ C_{27-29} steranes

The oils are produced mainly from Middle-Upper Devonian horizons with one sample from a Lower Carboniferous horizon. In the literature these reservoirs are described as residual soil structures of Paleozoic rocks, or as Paleozoic complexes. They are often porous, karst-type reservoirs in organic rich limestone, occasionally with admixtures of dolomite, or with layers of clayey limestone.

Distinct sources were recognized based on the general molecular composition (e.g. *n*-alkanes, isoprenoids, naphthalenes) of whole oil, saturate and aromatic fractions, in combination with detailed biomarker evaluations. Comparisons with other oils from the West Siberian Basin showed that the two main contributions were from the two well known Jurassic sources. A characteristic even over odd predominance of the C_{22}, C_{24} and C_{26} *n*-alkanes, a Pr/Ph ratio of around 1, a sterane distribution of $C_{27}>C_{28}\approx C_{29}$ (Fig.1), C_{30} steranes, and a $\delta^{13}C$ of the saturate and aromatic fractions of around -32 ‰ observed in several of the oils (e.g. Nizhne-Tabaganskoe, Yuzhno-Tabaganskoe) indicate that these can be correlated to the marine Jurassic Bazhenov source rock. A number of other oils (e.g. Maloichskoe, Urmanskoe, Severo-Ostaninskoe) are characterised by a sterane distribution dominated by C_{29} steranes (Fig. 1), C_{28} triaromatic steranes, $\delta^{13}C$ of around -29 ‰ and a more waxy appearance in the alkane distribution. These oils can be correlated to the more terrigenous influenced Jurassic Togur/Tyumen source. Both sources have contributed to oils in various Paleozoic reservoirs in both the western and the south-eastern area indicating significant contributions of Mesozoic oils to Paleozoic reservoirs.

Concurrently, several oils cannot be correlated directly to either Jurassic source (e.g. Eley-Igayskoe) and are significantly different with respect to their biomarker composition implying at least one other, possibly marine carbonate, source. Whether this source is Paleozoic in origin, or another Jurassic horizon is as yet unknown, although a carbonate source rock would have to be Paleozoic, as no Mesozoic carbonate source rocks are known to date. However, the presence of another source contributing to Palaeozoic reservoirs, in a basin that is dominated by Mesozoic source rocks, provides significant scope for future exploration in the West Siberian Basin.

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CHEMOMETRIC RESTORATION OF SOURCE-ROCK PALEOGEOGRAPHY USING BIOMARKER AND ISOTOPE COMPOSITIONS OF CRUDE OILS

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Biomarker and stable carbon isotope ratios were measured for >550 crude oil samples expelled from Upper Jurassic source rock in West Siberia, the North Sea, and offshore Labrador. A unique, multi-tiered chemometric (multivariate statistical) decision tree was used to classify seven genetically distinct Upper Jurassic oil families among these samples. The method, which we call decision-tree chemometrics, utilizes PCA (principal components analysis), multiple tiers of KNN (K-Nearest Neighbor), and SIMCA (soft independent modeling of class analogy) to classify and assign confidence limits for newly acquired oil samples and source-rock extracts.

Present-day geographic locations for each collected oil sample were restored to the paleo-latitude and paleo-longitude of the source rock during Late Jurassic time using the PALEOMAP Project© tectonic restoration program AutoPointTracker. Remarkably, predicted paleo-latitude and paleo-longitude based on partial least squares (PLS) analysis of the geochemical data closely correspond to those determined by tectonic restoration. For example, Family 3212 consists of 16 oil samples from the Norwegian and United Kingdom sectors of the North Sea. Tectonic restoration yields paleo-latitudes for these samples in range 48.0 to 56.8^{o}N. Predicted paleo-latitudes based on PLS of the geochemical data for these samples correlate with the tectonic paleo-latitudes (correlation coefficient, $r^2 = 0.98$). Likewise, Family 3214 consists of 68 oil samples from West Siberia and offshore Norway, Denmark, United Kingdom, and Newfoundland. Tectonic paleo-latitudes are in the range 45.8 to 67.0^{o}N and correlate with paleo-latitudes predicted by PLS of the geochemical data ($r^2 = 0.90$).