THERMAL MODELLING OF THE CRETACEOUS-NEOGENE HISTORY IN DOLNA KAMCHIA BASIN (ONSHORE BULGARIA)

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Introduction

The interest in the Dolna Kamchia basin during the last 25 years is connected with the results from the exploration in the Bulgarian part of the Western Black Sea and adjacent onshore areas (Fig. 1. A). Many oil companies were attracted (British Gas, Texaco, Enterprise Oil, OMV and others) carrying out significant amount of geological and seismic work (Benton, 1997). They drilled also several mainly offshore wells, which clarified the geology and enabled comparison with the rich onshore information.

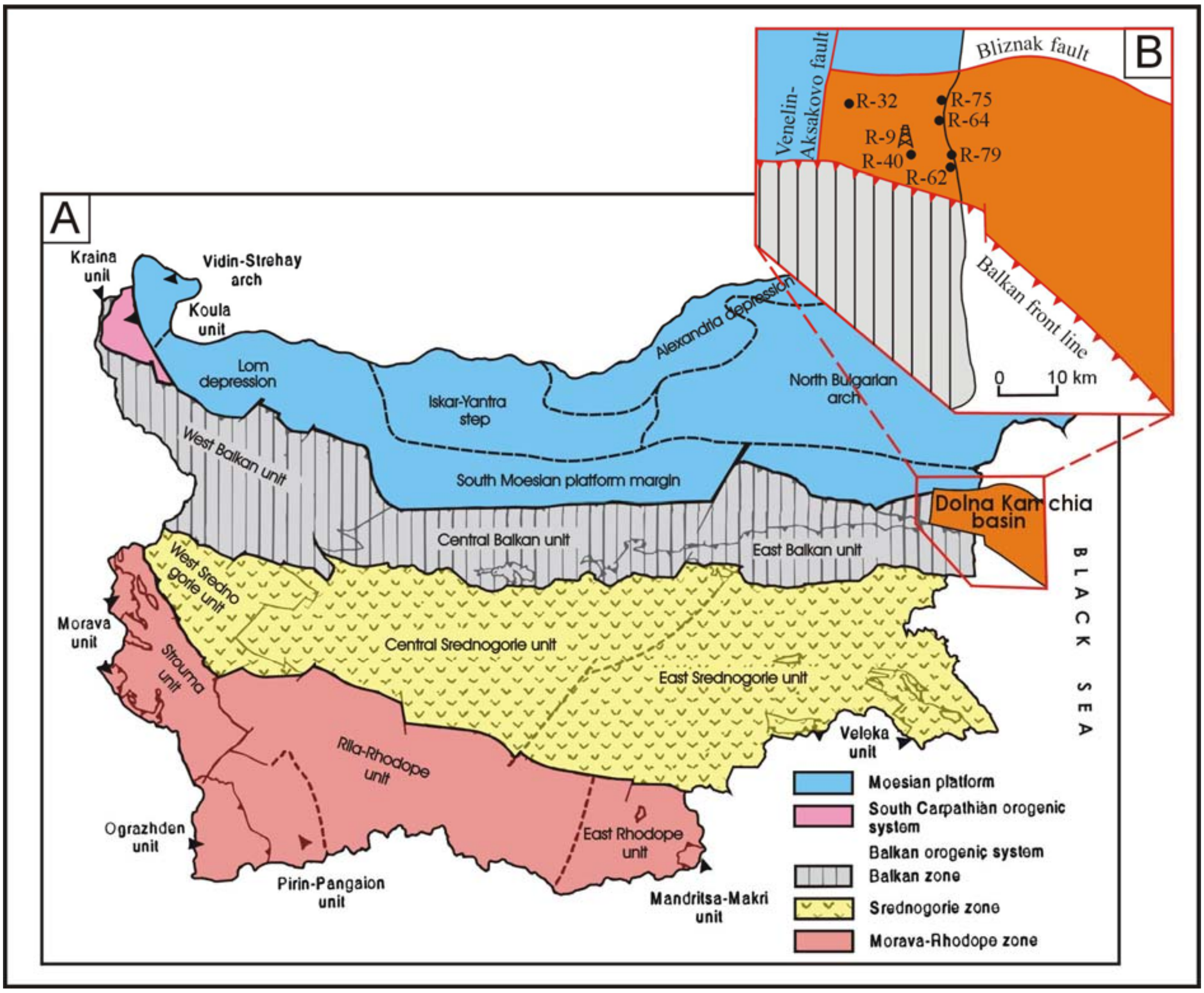

Fig. 1. A. Tectonic map of Bulgaria with the location of the Dolna Kamchia basin (after Dabovski et al., 2002 with modification); B. Studied area and onshore wells with the modeled R-9 Staro Oryahovo presented in Fig. 2 and 3 (tectonic boundaries after Georgiev et al., 2004).

Burial and heat flow history of the Dolna Kamchia depression should be viewed in the context of the development of a gradual and transitional zone toward the Western Black Sea basin. The thermal history in the regional aspect is determined and depends on the thickness and type of the crust as well as on the character of the tectonic processes.

The aim of the present study is the thermal history modelling of the Cretaceous-Neogene periods in Dolna Kamchia basin (onshore) according geodynamic evolution of the region and thermal maturity parameters. The well and maturity data allowed to define best fitting scenarios for the heat flow and paleotemperature distribution in the basin modelling.

Geodynamics of the study area

The Dolna Kamchia basin formed as a result of the Illyrian orogeny in East Balkan after Early-Middle Eocene (Georgiev et al., 2004), (Fig. 1. B). Paleogene-Neogene sediments filled the depression and cover transgresively the Upper Cretaceous deposits of the Moesian platform to the north and East Balkan to the south. Therefore, the Dolna Kamchia basin succeeded the Mesosoic evolution of the Moesian foreland. The Dolna Kamchia post-orogenic foredeep overlies the Albian-Upper Cretaceous sin-post-rift and Paleocene inverse periplatform sediments (Vangelov, 2000).

The Dolna Kamchia depression and Western Black Sea basin develop over the stable continental Moesian platform, considered as a part of the thick and and "cold" lithosphere (Spadini et al., 1996). The decisive impact on the thermal history is due to the opening of the Western Black Sea basin by back-arc extension, which began in the Middle or Late Barremian (Cloetingh et al., 2003), during Aptian-Albian (Nikishin et al., 2003) or Albian-Cenomanian (Dachev et al., 1988) and following long time thermal post-rift relaxation.

Methodic and data

The Illite-smectite geothermometry, vitrinite reflectance (%Ro) and basin modelling on well data as a standard technique for the reconstruction of paleo-heat flow and PDI-1D software of IES, Jülich are used to characterize the thermal history of the Dolna Kamchia onshore (Fig. 2, 3). Input parameters for the computer simulation include: the depth/thickness and time span of the lithostratigraphic units and erosion/hiatus events; lithology; paleo-water depths at the time of the deposition; and heat flow recovery for each event. The stratigraphic sequence is defined according the geologic time scale of Harland et al. (1990). The reconstructed heat flow history was calibrated with measured and calculated %Ro data, paleotemperatures recovered by different methods (Hower et al., 1976; Hoffman and Hower, 1979; Velde et al., 1986; Eberl, 1993) and present temperatures for studied wells. The well R-9 Staro Oryahovo is chosen as a representative for the onshore area and temperature recovery and temporal heat flow evolution are demonstrated in Fig. 2 and 3. The calculations of vitrinite reflectances followed the kinetic "Easy%Ro" aproach of Sweeney & Burnham (1990). The correlation of the geological events, expressed by the subsidence curves, to the thermal history and a calibration by organic maturity and/or time temperature parameters are therefore essential prerequisites for a successful numerical simulation.

Thermal history and modelling

The thermal history of the study area is characterized by a higher heat flow from the end of the Early Cretaceous, when the Western Black Sea basin is opened. The following post-rift thermal cooling in a regional plan lead to a gradual decreasing of the heat flow till its present values.

The territory of the development of the Dolna Kamchia depression, after the formation of the Western Black Sea basin, consecutively pass over several stages of epicontinental sin-rift (Cenomanian-Early Campanian); post-rift periplatform (Late Campanian-Maastrichtian); inverse periplatform (Early-Late Paleocene); pre-orogenic (Late Paleocene-Middle Eocene); post-orogenic basin (Middle Eocene-Oligocene), (Vangelov, 2000). During Neogene again predominate extensional conditions and from Late Miocene till present there is thermal contraction (Pavlova and Koleva, 1995).

Except for the heat generation and heat transfer in the lithosphere the thermal history is controlled by the tectonic processes. Therefore, we compare the basin subsidence curves for the defined events for well R-9 Staro Oryahovo with the temperature and heat flow distribution. The curves demonstrate two indicative phases of increased subsidence during Early Cretaceous (rifting) and during middle and late Eocene (foredeep development), when the maximum burial depths are reached (Fig. 3).

For the thermal modelling we use the paleotemperature reconstructions according to illite-smectite geothermometer compared to maturity hydrocarbon generation stages (Fig. 2). We confirmed the present heat flow with measured present burial well temperatures. The thermal history is constrained and calibrated with measured %Ro taken from well R-64 Longosa (Chouparova et al., 1993) and paleotemperatures interpreted according Eberl (1993) and converted to %Ro by equation of Barker (1988), (Fig. 3. A, B, C).

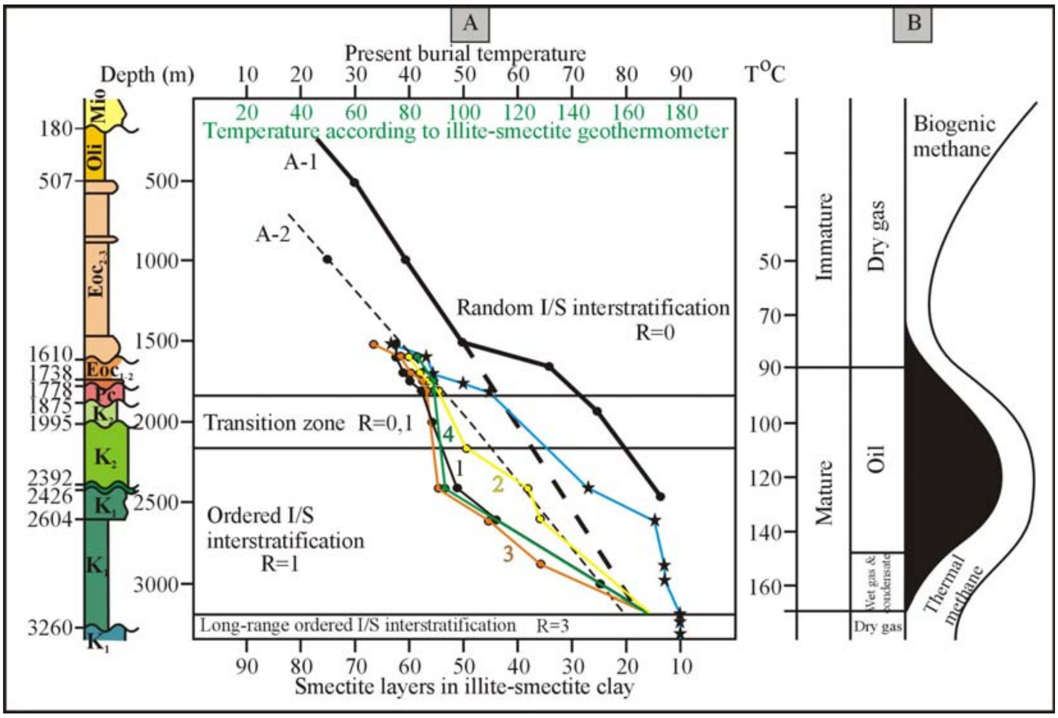

Fig. 2. A. Plot of depth vs. % smectite layers and ordering types in interstratified illite/smectite and depth vs. temperature from <2 micron fraction of core samples. The samples are interpreted according: 1. Oligocene well-black curve; 2. Miocene well-yellow curve; 3. Eberl (1993)-orange curve; 4. Hower et al. (1976)-green curve; A-1. Geothermal gradient at present burial depths-dashed line represent assumed position of the curve in depth; A-2. Reconstructed temperatures at maximum burial. B. Generalized relationship between temperature, hydrocarbon generation and changes in mixed layer illite/smectite (Hoffman and Hower, 1979; Rice and Claypool, 1981; Tissot and Welte, 1984).

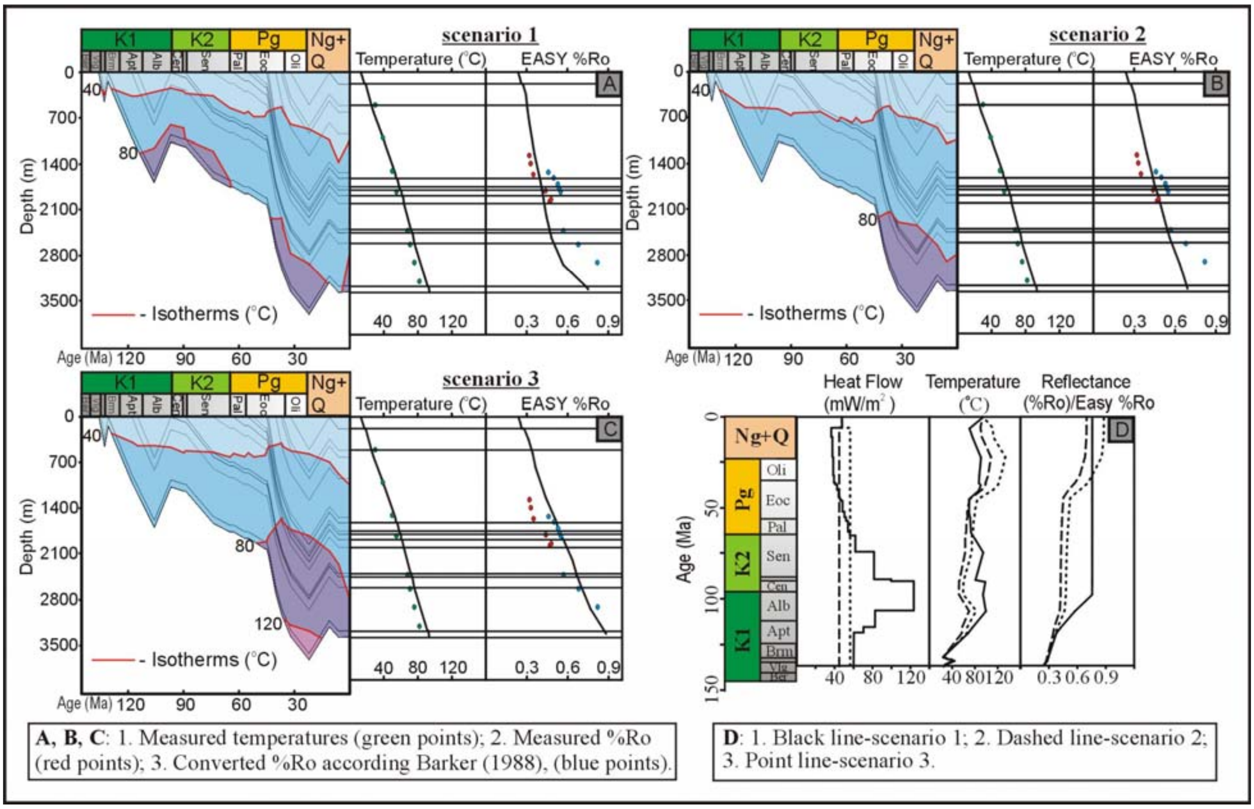

Fig. 3. Subsidence, temperature and heat flow histories of key well R-9 Staro Oryahovo. On the right (A, B, C), measured (dots) and calculated (lines) calibration data are shown.

We applied three heat flow scenarios (Fig. 3. D) using forward and inverse modelling in order to get the best fit between measured and calculated maturity parameters. The scenario 1 (Fig. 3. A) follows the heat flow model of Cloetingh et al. (2003). It shows relatively optimal coverage of measured maturity parameters only after the Illyrian orogeny. The constant heat flow scenario 2 (45 mW/m^2) covers just measured %Ro applied from well R-64 Longosa and underestimates the calculated %Ro according illite-smectite geothermometry (Fig. 3. B). The constant heat flow scenario 3 (57 mW/m^2) demonstrates good fit with blue dots and overestimates the measured %Ro (Fig. 3. C). The most plausible model could be expanded to the offshore and compared with the well data there.

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