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A COMPARISON BETWEEN 1D AND 3D BASIN SIMULATIONS OF THERMAL EVOLUTION AND HYDROCARBON GENERATION A CASE STUDY IN THE SOUTH MALAY BASIN, OFFSHORE PENINSULAR MALAYSIA

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One of the first steps when undertaking a basin modeling project is to define the thermal evolution of the study area via 1D thermal calibration. The resulting thermal model, often defined by heat flow maps, is then applied to subsequent 2D and 3D simulations. This study offers a comparison between 1D and 3D thermal modelling of the South Malay Basin and illustrates the need to re-calibrate the 1D thermal model before its application to a full 3D block simulation.

A systematic approach towards determining the top-of basement heat flow in the South Malay Basin was adopted, taking into account the three main heat sources of the basin: asthenospheric heat (β-factor dependent in rift settings) and radiogenic heat production from the crust as well as the sediments. Using basin modeling software, the heat flow variations through geologic time were determined by means of vitrinite reflectance (from standard measurement and FAMM methods) and measured present-day temperature data (from drill stem and production tests) as the main calibration points. Three top-of-basement heat flow maps for the different stages of the South Malay Basin development, namely the pre-rift, post rift, and the pre-inversion and folding phases were initially defined via 1D thermal calibration (Anuar et al, 2009). Having established the 1D-heat flow distribution patterns through time by incorporating the relevant stretching factors as determined by Madon & Watts (1998), these maps were then used as input for the 3D maturity modeling.

Calibrated heat flow values derived from the 1D models were applied to the 3D block. Resulting calculated and measured temperature and maturity data, however, highlighted noticeable differences between the modeled and observed temperature and maturity values in a number of wells (Figure 1). This illustrates the need to recalibrate the 1D-derived heat flow maps as they gave lower predicted bottom-hole temperatures and vitrinite reflectance values when applied to the 3D block model despite having been calibrated in 1D. It is concluded that, because 1D models do not capture the full basin geometry to enable complete thermal and fluid transport in space, they would often underestimate (although sometimes also overestimates) the observed temperature and pressure data. Throndsen & Wangen (1998) have shown considerable variations observed between

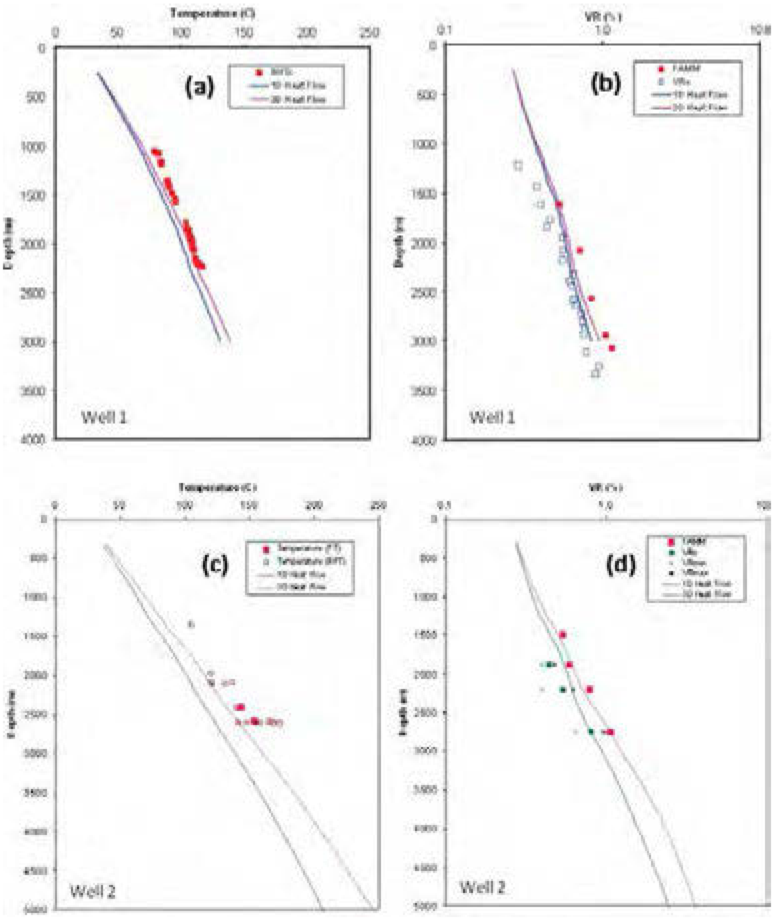

Figure 1. Temperature and maturity calibrations for Well 1 (a & b) and Well 2 (c & d) wells using the 1D derived heat flow maps (blue line) and the 3D-based corrected heat flow maps (red line). It is clearly shown here that the matching between calculated and measured data is better with the 3D-based corrected heat flow maps. FAMM data is considered as more reliable due to the vitrinite suppression phenomenon in the Malay Basin.

1D, 2D and 3D thermal models. The differences, among others, can be attributed to heat focusing, heat transfer through fluids, lateral variation in lithological properties and overpressure.

An optimisation was done by analysing the magnitude of differences between the modelled and actual temperature and vitrinite trends. Adjustments to the heat flows were necessary in order to match the modelled temperature and vitrinite reflectance values to those measured at the well locations. Subsequent shifting of individual heat flow values up and down, guided by the results at the calibration well locations, allowed a best fit scenario to be determined. The new and updated heat flow values were re-contoured and the revised maps (Figure 2) were then re-assigned to the corresponding time steps within the 3D model so that the temperature-dependent parameters, such as source rock maturation and hydrocarbon generation, can be calculated in the final simulation.

The establishment of the three new base-of-sediments heat flow models (present day and 16 Ma, 25 Ma and 40 Ma) enables all future thermal modelling work in the study area to be conducted with a higher degree of confidence, as these maps have been calibrated by the 3D basin modelling method. Corrections and further refinements can be made to these maps as more work is carried out in the study area.

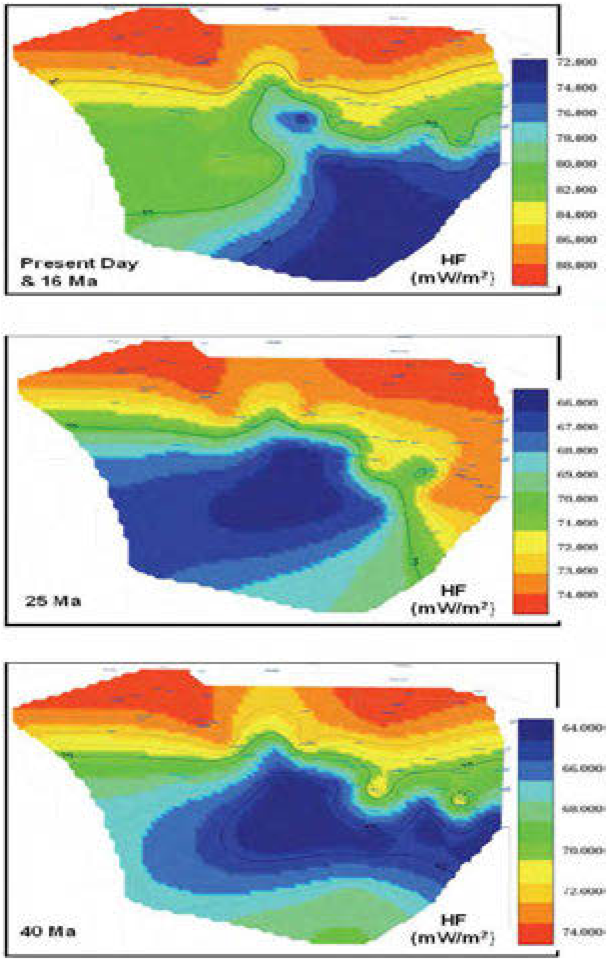

Figure 2. Final heat flow maps applied to the study area following adjustments of the initial maps derived from the earlier 1D thermal calibrations - present day & 16 Ma, 25 Ma and 40 Ma.

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