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Prediction of Carbonate Reservoirs Pore Pressure and Porosity in Onshore Abu Dhabi Using Petroleum Systems Modeling Technology

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Abstract

Prediction of pore pressure and porosity in an unconventional resource assessment area of Abu Dhabi was performed by using petroleum systems modeling techniques, combining seismic and well data and geological knowledge to model sedimentary basin evolution. The study objective was ultimately to reconstruct basin history and key geological structures as a basis for further geomechanical and fracture prediction studies. Twelve surfaces were interpreted from seismic data and derived from isopach maps. These maps were used to construct the basin model. The model was built from the top of the surface sediment down to the Shuaiba formation. Sediment decompaction was modeled, which enabled the reconstruction of the formation structures through time. Athy's law, formulated with effective stress, was used in the forward modeling simulator for the calculation of pore pressure. Information such as formation ages, erosional events, and hiatus periods were taken into account during simulation. The evolution of porosity, pore pressure, temperature, and thermal maturity through time were simulated and calibrated to measured data. Model porosity is dependent on burial depth, weight of the overburden sediment columns, and lithology properties. Porosity calibration was achieved by adjusting the compaction curve to effective stress. Pore pressure was calibrated by adjusting lithology porosity-permeability relationships. Low-permeability lithologies result in high pore pressure. A regional Paleocene pore pressure reduction was observed, caused by substantial erosion of the Simsima formation. Generally, formation overpressure is observed at greater depth. Additionally, modeled overpressures depend on the evolution of connate water vectors over geological time; these vectors depend on multiple lithology parameters as well as the capillary entry pressure of adjacent model layers. In the Shilaif fm, overpressure zones were identified at the anticlinal structures. Interestingly, higher overpressure was observed in the shallower anticlinal structure. The simulation results provide the estimated porosity and pore pressure in the unconventional play, as well as the reconstruction of the overall basin geometry through time. The resulting models were subsequently used as the basis for further fracture prediction studies; results were ultimately consistent with faults derived from existing seismic interpretation. Model porosity, pore pressure, and predicted fractures will be used for the development of static geological and dynamic reservoir models.