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Integrating Plate Tectonic Reconstruction and Mantle Dynamics: A valuable Aid in Frontier Exploration

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Effective hydrocarbon exploration in frontier regions requires an understanding of the tectonic and thermal evolution of basins, among other parameters or conditions. This is especially challenging when high-resolution local data are lacking, requiring reasonable interpolation and extrapolation of more regional knowledge. Some of the key first-order parameters influencing the presence and preservation of an economic petroleum system are the basin's vertical motion history and its thermal and stress evolution. To quantify these parameters in a physically consistent manner over several hundred million years, an integrated lithosphere-mantle dynamics modeling approach is needed. To this purpose, we embarked on developing a 3D dynamic model for the whole earth that links surface phenomena to mantle convection and lithosphere dynamics. The project involved a close collaboration between Shell and three universities, and integration of many disciplines and techniques. University of Lausanne developed 600-0 Ma global plate reconstructions with consistently evolving plate boundaries. The 300-0 Ma period was then adapted to be used as surface boundary condition for forward mantle convection modeling by Cardiff University, producing global predictions of base lithosphere temperatures, heat flow and mantle induced vertical surface motion through time. As a last step, Utrecht University developed a method to predict the lithospheric stress field through time based on integration of these mantle modeling results with the plate reconstruction model. This approach offers predictive scenarios and grids relevant to petroleum exploration that can be validated with local geological and geophysical data.