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Basal heat flow from crustal models for a forearc basin; San Joaquin Basin, California

Carolyn Lampe[1] and Lisa A. Alpert[2]

[1]Petroleum Systems Analyst, UCON Geoconsulting, Köln, Germany
[2]Exploration Geophysicist, Aera Energy LLC, Bakersfield, CA

ABSTRACT

The San Joaquin Basin lies west of the Sierra Nevada Mountains and east of the San Andreas Fault. Tens of kilometers of Mesozoic and Cenozoic sediments, including deep-water organic-rich source rocks, deposited in a forearc setting, comprise the basin and have contributed to a petroleum system that generates more than 70 percent of California's daily oil production and includes three of the 10 largest oilfields in the United States.

Based on a comprehensive 3D petroleum systems model of the San Joaquin basin, published by the USGS in 2008, we further refine the modeling to account for the unique depositional and tectonic history of the basin. Here, we compare various basal heat flow scenarios to model hydrocarbon generation and calibrate the results to available temperature and vitrinite reflectance (Vr) data. We investigate two types of crustal models: a McKenzie-type rift model, and a no-rift static crustal thickness model. Crustal stretching models calculate basal heat flow resulting from stretching/thinning of mantle and crust during initial (syn-rift) and thermal (post-rift) subsidence. This method uses rock matrix radiogenic heat production values. It does not account for transient effects resulting from burial and uplift of the basin fill. The static no-rift model, alternatively, calculates the basal heat flow based on a stable, or non-thinning crust and mantle over time. This method uses estimated Uranium (U), Thorium (Th), and Potassium (K) concentrations within the rock material to then calculate the rock matrix heat production. Unlike the rift model, it accounts for the transient effects resulting from burial and uplift of the basin fill, which can have a considerable additional effect on the basal heat flow.

Given the low probability of crustal stretching as the starting point for basal heat flow in the San Joaquin Basin and considering the forearc nature of the basin as well as the strong concentration of U, K, and Th in the Sierran granites, we focused on and refined the no-rift models. We manually account for the transitional nature of the San Joaquin basement from hot Sierran granite on the east to cool Franciscan oceanic rocks on the west. Radiogenic heat production (RHP) from solely continental crust results in models that are too warm and cannot be calibrated to well temperature and Vr data. Solely oceanic models are too cool to match well data. "Combined crust" incorporates a seismically derived suture zone that allows for a transition from oceanic to granitic basement, while the "intermediate crust" mixes oceanic and continental radiogenic heat production. These models generate a good match to well data to the east and westward through the transition zone. Additionally, we are able to calibrate to wells off of the Belridge (BR) and Lost Hills (LH) structures.