Basin Temperature Models Using Large Volume BHT Datasets — Advances in Methodology

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Abstract

Modelling of the subsurface thermal regime is important for understanding many aspects of petroleum systems, from thermal maturation of organic-rich source rocks to thermal risking of reservoirs and hydrocarbon accumulations. BHT measurements (~10x10^6 in onshore USA wells) offer a useful way to characterize the subsurface thermal environment, provided they are analysed in a way that reflects the lack of thermal equilibration implied by the generally short measurement times available during the drilling cycle. The key physical parameters affecting the BHT obtained from a wellbore are Time Since Circulation (TSC), Time Circulation Stopped (after drilling, TCS), thermal conductivity of the borehole contents and rock surrounds, drilling fluid temperature and heat flow from the surrounding rock. On a local scale, small data sets with high quality (i.e. recent) data, published methods of correcting BHT for lack of thermal equilibration rely mostly on TSC and TCS, both of which are commonly recorded, as in the familiar Horner method. These may be further corrected by comparison with long period DST derived temperatures. For large scale, low reliability, historical BHT datasets, different methods are used. Large datasets are generally manipulated to provide temperature vs depth regressions which are applied over a whole basin. The BHT data may be "corrected" prior to regression, using observed relationships against DST temperatures. Recent published works, and our own, have noted that the “corrected” solution often lies slightly above the maximum edge of the depth plotted BHT data. Over the past 6 years TGS has indexed 180,000 BHTs (and other well header information) from over 85,000 wells in 18 major onshore US & Canada basins. This provides a collection that is varied enough to provide insight into the usefulness of the main BHT affecting

parameters. We compare: BHT and TSC vs Depth patterns and TSC histograms from all 18 major basins. We examine the impact of varying the key rock and borehole parameters on the physical equations determining measured BHT and show that with large enough datasets, predictable trends emerge from random prediction of the main parameters that explain why many industry standard methods of BHT correction actually work. In practice, however we find that the accuracy of regression/correction methods may fail for a very simple reason - they tacitly ignore the fact that basins are generally not flat and that lithologies vary, laterally and vertically within a basin, especially for onshore US basins. They tend to use average geothermal gradients from surface to basement, ignoring the fact that interval geothermal gradients over discrete geologic layers vary markedly according to the layer lithology. We propose a method we have tested which uses the same technology, but on a layer basis, providing more accurate temperature models at all levels in the basin.