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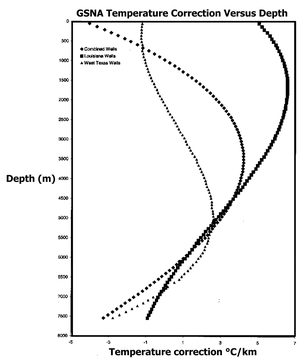
Calibration of the AAPG Geothermal Survey of North America BHT Data Base

Background:

The AAPG Geothermal Survey of North America (GSNA) was completed in the early 1970's, culminating the production of a massive data base of over 20,000 BHT points from over 10,000 wells in the US, Canada, and Mexico. From the collated data were publications of continent scale maps by the USGS (Kehle, 1970, DeFord and Kehle, 1976).

The AAPG made the data base available on CD-ROM in 1994. The data set has received only limited use, in part because of the uncertain error associated with the raw measurements, and the lack of calibration comparisons to accurate equilibrium temperature measurements. Two simple calibration corrections were applied, one for Louisiana and another ambiguously stated for west Texas.

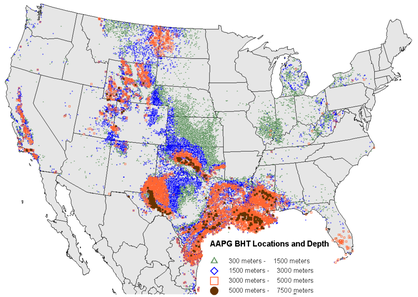


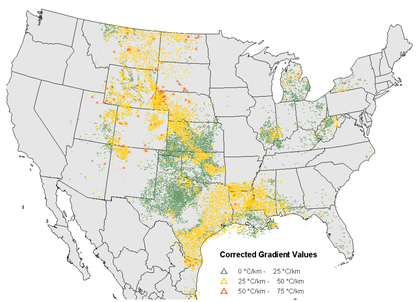
Harrison et al. (1983) used a BHT data calibration based mostly on drill stem temperature (DST) measurements in Oklahoma. Blackwell and Gallardo (1999) also had reasonable success in comparing BHT data corrected, using the Harrison equation, to thermal reconstructions for the Anadarko Basin in Oklahoma based on heat flow and conductivity modeling.

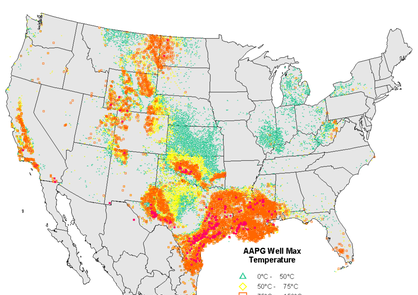
Thus in this study of the GSNA data base, we started from the Harrison correction. The Harrison et al. (1983) BHT Correction Equation is:

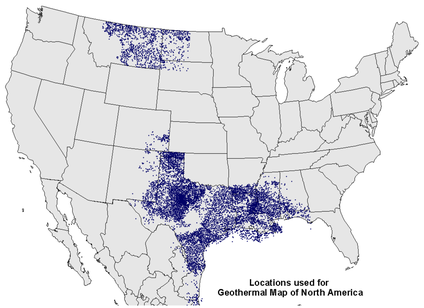
$$Tcf = -16.51213476 + 0.01826842109*Z - 2.344936959E-006*Z^2$$

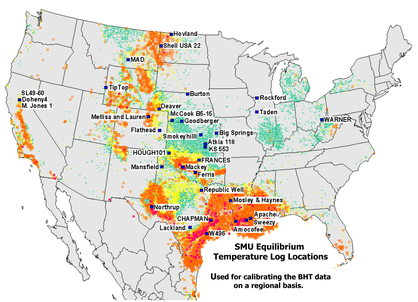
The Tcf values are subtracted or added to the original BHT values. Z is the depth in meters. This equation was only calibrated to a depth of about 3 km. The equation is similar to ones originally proposed by Kehle et al. (1970).











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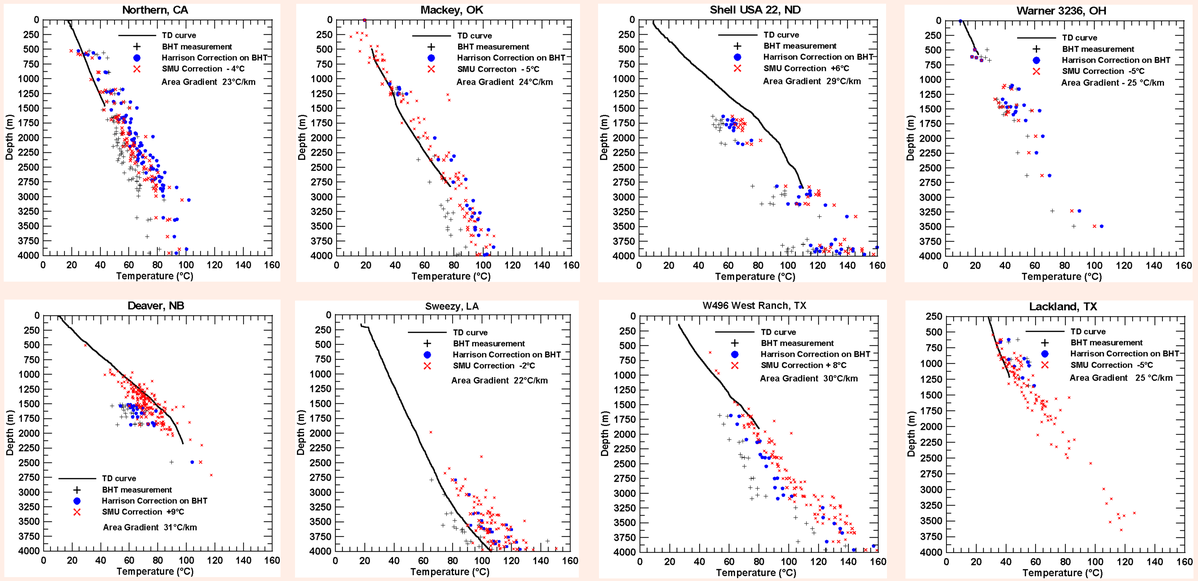


The raw BHTs values (black pluses in figures above) were first adjusted using the Harrison Correction (blue circles in figures above). In comparing these values to the equilibrium logs of 34 sites in the U.S., the values tended to be either too high or low with respect to the equilibrium temperature-depth logs.

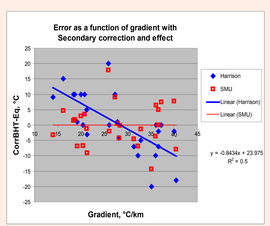
To improve on the Harrison Correction, it was determined that regional temperature gradients (±0.5° of latitude/longitude) played a roll. The Harrison corrected values were contoured for their gradient values and smoothed. From this, BHT site location gradient values were determined for a second correction (the SMU Correction). The SMU Correction added or subtracted amounts from the Harrison corrected BHT value, according to each well's regional gradient.

For wells with gradients of less than 20°C/km no change was made. Wells with gradients between 20 - 26°C/km tended to have temperatures too high, thus up to 5°C was subtracted. From 27 - 31°C/km the gradients were too low so values were added to the corrected BHTs respectively from 2-10°. Gradients over 30°C/km had a constant value of 11°C added to the temperature. In applying the SMU Correction, the BHT data and the equilibrium temperatures were more often similar (red x's in graphs above).

The SMU Correction did not always improve the regional BHT values with respect to the equilibrium temperature log. To reduce the potential of adding error by over correcting, we did not make any correction to gradients less than 20°C/km, and limited the maximum additional value of 11°C for the highest gradients. With the addition of the SMU Correction, the final calibrated temperature has an accuracy of about 5 - 10% based on the direct comparison of the equilibrium temperature logs.

The SMU Correction was applied to all the GSNA BHT data in the 750 to 3000 m depth range as a function of gradient. This corrected temperature was used to calculate well gradient. Thermal conductivity models, based on existing well data, were used with the new gradients to obtain heat flow estimates for the Northern Great Plains and Gulf of Mexico (including Mexico) for the new Geothermal Map of North America (Blackwell and Richards, 2004).

The correction below 3 - 4 km is still not established with enough accuracy to be consistently used. If equilibrium logs are available to calibrate the regional data, then it is possible to use. The correction should decrease with depth below 3 to 4 km, but there are not enough data to quantify the form of the decrease into one equation for the U.S.



The mean temperature differences between the measured (equilibrium wells) and the two calculated corrected temperatures are shown in the Figure to the left. These represent about 20 sites in the Midcontinent and Gulf Coast with depth ranges of 2500 ±500 m. The differences are plotted as a function of gradient. In ½ of the sites the error on the SMU corrected temperatures are less than 5°C and averages near 0. Thus it is the best correlation between the error and the gradient.

There are clearly anomalies. The **Lackland well** in Texas is colder than the surrounding BHT's in the deeper portion. Yet the equilibrium log is linear and there is no obvious effect of cold downflow in the well. Several of the deeper wells are geopressured, (**Sweezy, LA**) suggesting that the recovery may have been faster than in normally pressured wells. On the other hand several wells with high gradients have very large errors. As a result the tendency when using the BHT data is to miss the highest and lowest gradients in an area.