PRELIMINARY DISCUSSION OF GEO-THERMAL GRADIENTS IN OKLAHOMA OIL FIELDS

JOHN A. McCUTCHIN, AMERICAN PETROLEUM INSTITUTE

THIS WORK is carried on by the American Petroleum Institute as their project No. 25A, under the personal direction of Dr. Chas. N. Gould, director of the Oklahoma Geological Survey.

The problem has for its object a two-fold purpose; the scientific investigation of the heat distribution in the earth's outer lithosphere, and an intensive study of the temperature variation in Oklahoma oil fields.

The thermometers used are mercury-glass thermometers of the maximum type, accurate to two-tenths of a degree F., graduated to 1° F., and read to one-tenth of a degree by means of a thermometer reading telescope.

They are lowered on a No. 15 piano wire, readings being taken every 250 feet from the top to the bottom of the hole, thus obtaining a temperature survey of the well rather than a few isolated readings. Three thermometers are used at each point and the mean temperature of the three taken as the observation. The thermometers are lowered in sealed steel tubes, when the reading is taken below fluid level, and in perforated brass tubes when the thermometers are suspended in air.

The machine consists of a machined measuring wheel geared to a mechanical counter which records the depth in feet. A reel, about a foot in diameter and three inches across the face, is provided for spooling the piano wire. The reel is equipped with two handles for winding the thermometers out of the hole, and a brake for lowering them into the hole. A device called a cylindrical cam with a zero period of rest spools the wire evenly across the face of the reel. The whole machine is mounted on a four-legged stand and guyed to the derrick floor by means of spikes and turn-buckles. This apparatus is described in detail in Economic Geology, vol. 19, No. 3, pp. 229 to 248, "Apparatus for the measurement of Temperature in Deep Wells by Means of Maximum Thermometers."

USING THE DATA OBTAINED FROM THE WELL

If the temperature be plotted along the Y axis and the depth along the X axis, a Depth Temperature Curve is obtained. If the well is in temperature equilibrium the Depth Temperature Curve will be approximately a straight line, concave slightly toward the depth axis and with a small increase in curvature with depth.

If the curve be extended back to the Y axis, or the point of zero depth, a temperature which may be called the computed mean annual soil temperature for that point is obtained. This computed mean annual soil temperature is always higher by about 2° to 5° F. than the mean annual air temperature as given by the United States Weather Bureau. This fact is significant in that it shows the earth to be losing heat to the atmosphere, and that the earth's heat is in a kinetic state rather than in a static state.

The following temperatures were obtained from a deep well in the Tonkawa field:

GYPSY OIL COMPANY LEE SHOWVER NO. 85

Depth in feet	Temperature in degrees Fahrenheit
100	63.46
500	71.29
1000	80.16
1500	90.25
2000	99.55
2500	106.58
3000	119.70
3500	132.19
4000	144.14

Mean Annual air temperature 58.9°F.

The gradients are obtained from the observations by putting a straight line through the observed temperatures by the Least Square method. This gives a solution for the constants "a" and "b" in the general straight line equation, Y = a plus bX, where Y equals the temperature, "a" the computed mean annual soil temperature, "b" the gradient in degrees Fahrenheit per foot, and X the depth in feet. The first derivative of the general equation gives "b" the gradient in degrees per foot. This value is always a small decimal and not so easily understood as the reciprocal 1/b which gives the number of feet per degree Fahrenheit. The reciprocal gradient is used in this work.

The gradients vary to a considerable extent from area to area in Oklahoma, and perhaps to a small degree within the same area. The gradient observed in southern Oklahoma at Healdton, Hewitt, and Walters is about one degree in one hundred to one hundred fifty feet. The gradient at Seminole, Wewoka, Cromwell, Tonkawa, and El Dorado, Kansas, is about one degree in fifty feet.

While the gradient seems to be practically constant from the center of the fields to the sides, I find that if the depth to some chosen temperature—say one hundred degrees—be computed, and the Iso-thermal surface determined, that this Iso-thermal surface coincides quite regularly with the outline of the field.

The author realizes some of the limits and difficulties of the problem. All the observations have been taken in oil wells, either in or adjacent to proved anticlines or oil pools. It is possible that geo-thermal anticlines are present where no structural anticlines exist. Such factors as density, porosity, degree of saturation, mineralization, solution and deposition of minerals, no doubt have an effect, and may be the main factors.

About all that can be said in the way of conclusions at this stage of the work is that with the collection of more data the results seem to be encouraging rather than disappointing.