DEEP WELL TEMPERATURES IN OKLAHOMA

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ABSTRACT

The American Petroleum Institute is carrying on an extensive investigation of the geothermal gradients in the California, Texas, and Oklahoma oil fields, the purpose of which is to determine the possibility of using temperature data for the location of future oil pools. Data collected to date indicate that the geothermal gradients in Oklahoma are related to proved anticlines and to the regional dip of the rocks. This paper gives a preliminary discussion of the problem in Oklahoma.

INTRODUCTION

The question of the internal heat of the earth has long been a subject which has interested geologists and other scientists. Many scattered temperature observations in deep mines, hot springs, and artesian wells were collected and published in a United States Geological Survey publication by N. H. Darton in 1920.

About ten years ago Dr. C. E. Van Orstrand of the United States Geological Survey began making observations in deep wells by lowering maximum thermometers on a piano wire. A number of these observations made at Salt Creek Dome and other Wyoming fields revealed that the isothermal surfaces in these fields coincided to a marked degree with the geologic structures.

These observations attracted the attention of petroleum geologists for it was quite evident that if the geologic structures were related to the heat distribution in the overlying rocks, conversely the subsurface structures might be revealed by measuring temperatures in shallow drilling wells or core drill holes. It was with this idea in mind that the American Petroleum Institute authorized this work in three of the major oil producing states; Texas, California, and Oklahoma.

APPARATUS

The machine used to lower the thermometers into the wells, consists of a steel frame and measuring wheel which accurately 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 well, and a brake to facilitate lowering them into the well. A device called "a-cylindrical cam with a zero period of rest" spools the wire evenly across the face of the reel and thus prevents the transmission of impacts to the thermometers due to the coils of wire piling upon each other and slipping off. The whole machine is mounted on a four legged stand and guyed to the derrick floor by means of turn buckles to prevent vibration as the thermometers are raised or lowered.

The thermometers used are mercury in glass thermometers of the maximum type with very tight constrictions which prevent their being shaken down easily when they are hauled from great depths. Three thermometers are lowered to each point and the average reading of the three is taken as the temperature of the rocks at that point. The thermometers are inclosed in perforated brass tubes when the readings are taken in air and are left suspended for an hour and a quarter at each point. When the reading is to be taken below the fluid level in a well the thermometers are held in sealed steel tubes which are left suspended in the fluid forty-five minutes.

Observations are made at 100 feet and every 250 or 500 feet thereafter to the bottom of the well, thus obtaining a temperature survey of the hole. The temperature at 100 feet is usually two to five degrees Fahrenheit higher than the mean annual air temperature of the area where the well is located. This gives a very good indication of the state of temperature equilibrium which the well is in. Only thq data from wells which are in temperature equilibrium are considered. The average time for completing a test of a 3,000 foot well is one and one-half days.

ACCURACY OF THE OBSERVATIONS

Every effort is made to make highly accurate observations. The thermometers are constructed accurate to two-tenths of a degree Fahrenheit and are read to one-tenth of a degree by means of a thermometer reading telescope. At least one new thermometer is run with each set of three in order to prevent the low and inaccurate readings shown by thermometers which have been used for some time. When any thermometer is observed to read as much as three-tenths of a degree low consistently it is discarded. The depth temperature curves for each well are plotted in the field and when any observation is seen to fall off the smooth curve, the observation is repeated. With this type of apparatus it is believed that an accuracy of 0.2 to 0.3 of a degree Fahrenheit can be maintained.

HOW GRADSENT IS REACHED

After the test has been completed the gradient is determined by the following method which may be found described in detail in "A Method of Least Squares,"—Text Book, Merriman.

The observations are plotted on a set of rectangular coordinates with the depth in feet along the X axis and the temperatures in degrees Fahrenheit along the Y axis. Next a straight line is put through the points by a least square method, thus obtaining the values for the constants "a" and "b" in the general straight line equation—a plus bX equals Y. In which "a" and "b" are constants, X is the depth and Y the temperature. After the constants are evaluated the first derivative of the equation is taken which gives the slope of the line which is the value of "b," the gradient. This value is always a small decimal fraction and represents the number of degrees Fahrenheit increase for one foot of depth. The reciprocal gradient, which is the number of feet increase to give an increase of temperature of one degree, is the value best understood and will be referred to hereafter as the gradient.

These gradients vary considerably from area to area in Oklahoma and to a smaller degree within the same area. A gradient as low as one degree in 150 feet was observed in Healdton, Carter County, field, while a gradient as high as one degree in 36.5 feet was observed in a well located near Sapulpa, Creek County.

EXPLANATION OF TEMPERATURE CROSS-SECTION

The isothermal surfaces dip to the west in a manner which approximates the dip of the geological formations across this area. They also converge to the east. For example, the depth to 100° F. near Sapulpa is about 1,500 feet, while the depth to the same temperature in the well located near Oklahoma City is about 4,300 feet. No satisfactiory scientific explanation has been offered to account for this variation.

CONCLUSIONS

While the data collected to date on this problem are by no means sufficiently complete to permit other than preliminary conclusions, as a whole they do tend to support the general idea that the anticlines in Oklahoma which have been productive of oil and gas have higher temperatures at given depths than the areas surrounding these anticlines. The variations within the individual fields are usually small but quite uniform. There also seems to be a relation between the regional dip of the rocks and the depth of the isothermal surfaces.