

A careful study of these variations has recently been made by Königsberger and Mühlberg. According to these authors:

It may be assumed that all over the earth in flat countries where the sub-soil consists neither of comparatively recent eruptive rocks nor of deposits liable to change, there prevails a normal geothermic gradient. All deviations from the normal gradient are due to local influences: uneven surface of soil (mountains, valleys), the presence of great reservoirs of water (lakes, the sea), and heat producing processes in the interior of the earth or incompletely cooled eruptive masses.¹

The average of the gradient of 32 borings in flat country in rocks which are neither of eruptive origin nor subject to considerable chemical alteration is given by Königsberger and Mühlberg as 1° Centigrade in 32.9 meters.

The geothermic gradient adopted as shown in Fig. 1 is based on this value.

The view that this temperature gradient continues uniformly downward in the earth's crust has been controverted by Strutt, who from investigations into the radio-activity of the rocks of the earth's crust concludes that the temperature rises uniformly to 1500°C., and then remains constant at that temperature to the center of the globe. This conclusion, however, does not affect the consideration of the present question, seeing that this temperature would not be attained until a depth had been reached which is much greater than those whose temperatures are made the subject of study in the present paper.

THE EXPERIMENTAL METHOD EMPLOYED

Two rocks were employed in this investigation and two series of experiments were carried out with each.

In the first series with each rock, the attempt was made to reproduce the conditions of pressure to which rocks are subjected at various depths within the earth's crust, both as to intensity and, as far as possible, as to duration; while in the second series of experiments the third element of temperature was also introduced.

¹J. Königsberger and Mühlberg, "On Measurements of the Increase of Temperature in Bore Holes, etc." *Trans. Inst. of Mining Engineers*, London, 1910, XXXIX, Pt. IV, 9.

In every experiment a column of the rock, very accurately ground to the dimensions of .5 inch in diameter and 1.57 inch long, was taken and through it two holes were drilled. These holes were, as nearly as possible, .05 inch in diameter. One of these passed through the vertical axis of the column from top to bottom. The other passed transversely through the middle of the column, being at right angles to the other hole but a little to one side of it, so that the two holes did not actually intersect. A wire was then drawn to fit the hole exactly, so that the slightest change in the diameter of the hole could be detected by passing the wire into it.

A round bar of nickel steel, $3\frac{1}{4}$ inches long and $2\frac{1}{2}$ inches in diameter, was then taken and a hole very slightly smaller in diameter than the rock column was accurately drilled through it in the direction of the longitudinal axis. This bar was then heated slightly, and thus expanded just sufficiently to allow the column of rock to be slipped in so as to occupy a position in the middle of this bar or thick-walled tube. The tube was then allowed to cool. The perforated rock column enclosed in its steel tube is shown in Fig. 2. The rock was thus held firmly on all sides by the steel, but the size of the hole was such that the shrinking of the tube upon the column did not compress the rock more than was required to effect a perfect mechanical fit, and in this way to give the requisite lateral support to the rock when the latter was submitted to compression in a vertical direction. Preliminary experiments showed that this operation did not in the slightest degree affect the size of the holes which had been bored through the column, and also showed that if the latter were unsupported below, a load of 7,250 lbs. on its upper end would shove it down through the tube.

If the experiment was to be conducted at ordinary temperatures, a disk of paper was then placed on either end of the column to equalize the pressure and two pistons of hardened "Novo" steel, ground so as to pass easily into the ends of the tube were inserted, by means of which pressure could be brought to bear upon the enclosed column. The whole was then placed in a powerful press and the enclosed rock submitted to a pressure equivalent to any required depth beneath the surface of the earth for a period