Temperature Gradient in the Earth's Crust.

SOME observations on temperatures in a deep bore-hole in South Africa were described by L. J. Krige and H. Pirow in June last before the Geological Society of South Africa. The bore-hole, which had been made in search of oil, is situated on the Dubbeldevlei Farm, near Carnarvon, at an elevation of about 3250 feet above sea-level. The country is flat and underlain by nearly horizontal strata assigned to the Ecca, Dwyka, and Fish River series. These rest upon granite and gneiss at a depth of 2687 feet. The bore-hole had been carried to a depth of 5080 feet, but the lower 160 feet had become silted up. The observations on temperature ranged from the surface down to a depth of 4912 feet, and were successfully made at 26 levels. Water stands in the hole at 32 feet from the surface. The upper 1100 feet of the hole is lined with $3\frac{1}{2}$-inch casing. From 1100 feet to 3000 feet the diameter of the hole is $2\frac{15}{16}$ inches; it is then $2\frac{5}{8}$ inches to 4500 feet, and $2\frac{1}{16}$ inches from that point to the bottom.

The thermometers used were of the clinical type (that is, constricted between the bulb and the scale) and were enclosed in a brass tube 5 feet long and of $1\frac{3}{4}$ inches external diameter. They were lowered by wires, and as a result of some preliminary experiments were left at the point of observation not less than four hours in order that the true temperature should be acquired. This seems a short time, but as a fact two readings made after $4\frac{1}{4}$ hours and $11\frac{1}{2}$ hours respectively had been found to be identical.

The observations showed that the temperatures were affected by seasonal variations to a depth of 55 feet. Below this depth they ranged from 22·25° C. (72·8° F.) at 75 feet depth to 69·75° C. (157°·5 F.) at 4912 feet. They rose with depth at a maximum rate of increase of 1° C. in 60 feet in the upper part and at a minimum rate of 1° C. in 140 feet in the lower part of the hole. Plotted graphically they form a curve of considerable regularity, but becoming steeper as the rate of increase decreases with increasing depth. The curve, however, shows certain irregularities which indicate that some other cause than increasing depth is affecting the rate of increase.

On associating the curve with a geological section of the bore-hole it becomes apparent that the irregularities, and indeed the curve itself, are determined by the relative conductivity of the strata traversed. Thus the upper part of the Ecca series is composed of shales of low conductivity; in these the rate of increase is uniform at 1° C. in 60 feet. The lower part of the series includes hard shales with calcareous nodules and a sheet of dolerite 135 feet thick; in these the rate varies from 1° C. in 80 feet to 1° C. in 100 feet. Below this, in another thick bed of shale in the Dwyka series, the rate rises to 1° C. in 85 feet, but still lower in the massive Dwyka tillite and sandstone it falls to 1° C. in 125 feet. Again, in the Fish River series, it varies from 1° C. in 105 feet in sandstone and shale to 1° C. in 90 feet in some thick shales below. The lower part of the series consists of layers of shale mixed with grit and sandstone, and in these and the granite and gneiss on which they rest, the rate varied from 1° C. in 120 feet to 1° C. in 170 feet, the mean value being 1° C. in 149 feet. The highest rate in the granite and gneiss (1° C. in 120 feet) was observed in a cavernous bed, the cavities in which were assumed to cause low conductivity.

In all cases the more rapid rates of increase are associated with the lower conductivities of the rocks, the badly conducting strata, or bands in the gneiss, acting as blankets. The worst conductor, as shown in a table published in the Report of the British Association for 1881, is shale, and among the best are quartzites, sandstones, dolerite, and granite; gneiss, limestones and soft sandstones occupy an intermediate place. All of these make their presence felt in the modifications of the curve of temperatures.

The author's remark that the measurement of underground temperatures and the calculation of the geothermic gradient have not much value if the nature and dip of the rocks pierced are not studied, seems to be well justified. Obviously an occasional observation, in place of a connected series, would be more likely than not to give a wrong impression of the gradient. In my own limited experience of such work the results were so far vitiated from this cause as to be useless. They were obtained in the Talargoch Lead-mine in North Wales with all possible precautions, but showed 5° F. difference at the same depth in different parts of the workings. I concluded that "the great differences in the rate of increase of temperature in different parts of the mine may perhaps be due to the very faulty nature of the ground. In some cases the rock overlying the point of observation was principally shale, in others limestone, in part thick-bedded and massive, in part thin-bedded and shaly" ("The Geology of the Coasts adjoining Rhyl," etc., Mem. Geol. Survey, 1885, p. 58). Many of the observations made in Great Britain have been carried out in shafts or bore-holes in Coal Measures, made up of numerous alternations of sandstone, shale, and clay, sometimes horizontal but more often inclined. Presumably the temperature-curve in such cases, if sufficiently detailed, would show a number of zig-zags, and it would be a matter of chance whether or not a correct conclusion could be drawn as to the general gradient.

The paper emphasises the difficulty of obtaining sufficiently accurate data for calculating the rate of increase of temperature in the crust of the earth from observations made in the thin film which alone is accessible to us.

A. STRAHAN.

Radiography of Mummies.

FOR the first time in America, X-ray photographs of mummies were taken recently. This has been made possible by a series of experiments begun at the Field Museum of Natural History, Chicago, and the satisfactory results already obtained will doubtless open a new and important field of operations in the scientific world.

The experiments were started by X-raying a group of Peruvian mummy packs from the Necropolis of Ancon. These had been collected for the World's Columbian Exposition, held in Chicago in 1893, and since have been in the possession of the Museum. To have unwrapped these mummy packs to ascertain whether they contained objects of special interest would have meant their destruction for exhibition purposes. By means of the X-ray pictures it is possible to learn what has been buried with the body, thus determining beforehand whether or not it be advisable to unwrap the bundle.

In the mummy packs thus far examined have been found ears of corn, pottery, vessels of clay containing shells, bits of metal, gourd vessels, beads, clay figurines, cut-bone objects—or, in some instances, nothing. In addition to the range of objects found