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HYDRO-GEOLOGY AND HYGIENE.*

BY C. E. DE RANCE, OF H.M. GEOLOGICAL SURVEY.

The term hydro-geology, to express the study of the passage of water when, as rainfall, dew, or snow, it reaches the surface of the ground, or percolates beneath it, appears to the writer to deserve more general acceptance than has been accorded to it. It appears to have first been used by a French Jesuit priest about half a century ago, and was adopted by Mr. Lucas in his studies on the chalk-water supply of the south of England 20 years since.

A Lancashire squire, one of the Townleys of Townley, near Burnley, appears to have been the first to systematically observe the amount of rain falling more than 200 years ago; a century later, in 1766, a rain gauge was placed on the top of the square tower of Westminster Abbey by Dr. Heberden, F.R.S. Early in 1861, G. J. Symons, F.R.S., began his magnificent organization; his modest pamphlet of four pages of that year, with 168 observers, has now blossomed into a volume of 254 pages, with a staff of 3,043 observers. Looking to the bearing of the inquiry on manufacturing, engineering, agricultural pursuits, and the health of the inhabitants, it is remarkable that such an investigation should be left by the nation to the self-abnegation and industry of this remarkable voluntary effort. Mr. Symons' annual volume is a record of the nation's "Water Revenue," on which depends the amount available to be consumed by men and animals, to be absorbed by agricultural crops and forests, or utilized in manufacturing processes, purposes of inland navigation, the production of steam and electric energy, and the preservation of fisheries. From the amount recorded, large amounts have to be written off from several causes, which probably vary from year to year: (1) Evaporation, which is governed by the comparative dryness or wetness of the air at the moment of the rainfall; (2) the amount percolating, which varies also according to the comparative dryness or wetness of the soil, in dry periods vegetation taking up a very large proportion, and, indeed, after long periods of drought the whole of the volume percolating is so arrested, and none sinks to replenish the underground storage; and (3) lastly, there is loss from transit of percolation water into areas where the supply cannot be obtained by pumping. This is the case when the sectional area of a porous rock, where it dips and disappears beneath overlying impermeable material, is sufficient to discharge the water into outside areas—*i.e.*, tidal rivers on the sea. Of the rainfall that is absorbed by the area of outcrop of the porous rock, nothing goes into the streams until rainfall additional to the amount that runs to waste causes the saturation level in the porous rocks to rise above the level of the V-shaped valleys which intersect it, and in the case of dry valleys, a "bourne," or temporary stream appears.

Before dealing with the loss to be "written off" the annual "water revenue" falling as rain on impermeable rocks, it is desirable to state some facts as to the comparative area occupied by various classes of rocks and their varied degree of porosity. If a geological map of England and Wales and a hydrographical map showing the rainfall be compared, it will be at once seen that the hardness of the Lower Palæozoic rocks has caused them to form the three highest areas, viz., Dartmoor, the Welsh and Cambrian mountains. These receive the highest rainfall, and as they almost wholly consist of impermeable material, they throw off the rainfall in floods, and are drained by rivers in which the flood discharge and the dry-weather flow is utterly disproportionate. Were it not for the arresting influence of peat mosses these streams would in dry periods be still more insignificant. The discharge is often 500 cubic feet per second per 1,000 acres drained in flood, and only ¼ cubic foot off the same area in dry periods. Probably one-third of the annual rainfall runs off in floods, and unless it is caught in storage reservoirs, such as Manchester and Liverpool have made, and Birmingham is making, the whole of the water for potable purposes is lost, as it becomes polluted as it passes to the sea; and to a large extent it is lost for all purposes, as the flood is sudden, the flow great, and the gradients of the river bed steep, and all that is not caught must be written-off for "depreciation caused by floods." It is fortunate for the centres of large population in this country that, from the conditions of life directly produced by the geological character of the elevated areas referred to, they are areas of the least population in England and Wales, and, except to a slight and unimportant extent, due to mining, no pollution of these upland waters takes place. Further, the very important ad-

*Paper read before the British Association of Water Works Engineers at Nottingham, July 21, 22 and 23, 1896.