Of Dr. Buckley's explanation, p. 383, of the unfavorable action of freezing temperatures, Mr. Merrill says there is 'an unconvincing air of freshness.' For my own part, I think Dr. Buckley is correct in his explanation of the resistance which many porous rocks, like sandstones, exhibit to alternate freezing and thawing, while other rocks which may contain no more than one per cent. of pore space suffer severely under such conditions. This matter cannot be fully expounded in this review, but Dr. Buckley's explanation in brief is that in rocks in which the pore spaces are large and connected, the water is drawn off or distributed by capillarity, leaving the pore space only partly filled by water. When this water freezes there is room for expansion within the pores without rupturing the rocks. On the other hand, in some rocks in which the pore spaces are very small and discontinuous, the pores remain entirely filled by water, and when they freeze the expansion ruptures the rock (pp. 20–25, 374–375). Dr. Buckley's conclusion is fully warranted by his experiments, which show that fine-grained, compact limestones and granites which have a very small pore space, often lose more in strength by freezing and thawing than do the sandstones having a large percentage of pore space. I am not aware that experiments have before been made which show the actual effect of freezing and thawing on the strength of the rocks. Nor have experiments shown the relation of the size of the pores to the diminution in strength due to freezing and thawing, and Dr. Buckley's results on this point are believed to have economic value. However, whether this be so or not, they have a scientific value bearing on the disintegration of rocks in the belt of weathering.

Another matter discussed, upon which Dr. Buckley has made a contribution of general value to the science of geology, is the more accurate determination than has heretofore been done of the pore space of rocks. Tolerably well indurated sandstones he finds to vary in pore space from 10 to 20 per cent. or more, and in one case, that of the Dunnville sandstone, the pore space is over 28 per cent. (pp. 402–403). These results are of great importance as showing the actual amount of material which must be added by underground waters in order to completely cement a rock. From Dr. Buckley's results it is a safe inference that in the cementation of clean sandstones to quartzites, there must have been contributed by underground waters at least one-quarter of the entire volume of the rocks. In determining the pore space of building stones, their specific gravities have also been obtained by a method more accurate than has heretofore been used.

Dr. Buckley's observations on joints in the State of Wisconsin (pp. 458–459, Pl. 49) have an important bearing upon structural geology. These observations are shown upon the map and indicate that the dominant joints of the sedimentary rocks of Wisconsin are in nearly vertical position and in two sets nearly at right angles to each other, trending NW–SE and NE–SW. The position of these joint systems with reference to the folding has an important bearing upon theoretical structural geology which cannot here be discussed. In connection with certain structural work of my own I have searched for such information in many volumes, but nowhere else have I found a set of observations upon joints over so wide an area.

In conclusion it seems to me that the size of Dr. Buckley's book is justified by the necessity of putting in a State report the information which the people of the State wish. It seems to me further that the report differs from a number of previous State reports in containing considerable material which is of general value to geology.

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HYDROSTATIC VS. LITHOPIESTIC THEORY OF GAS WELL PRESSURE.

THE paper read at the Orton Memorial Meeting at Columbus, entitled 'Edward Orton Geologist,' and published in SCIENCE, January 5th, contains a reference to Professor Orton's theory of nature of gas and water pressure in gas wells that calls for some comment.

The writer has for some time not been entirely satisfied with the 'Hydrostatic Theory of Gas Pressure.' He noticed that Professor Orton, himself, a short time before he died, expressed himself in a way as to indicate he was not altogether satisfied with his own theory.

Certain wells had been bored in New York that exhibited a pressure of 1500 pounds to the square inch. Professor Orton confessed that he was unable to suggest where the hydrostatic head sufficiently high to produce this pressure might be located; though in explaining the pressure in the Ohio and Indiana Trenton gas wells, he had gone as far as Wisconsin to get a head sufficient to explain pressures of approximately 450 pounds to the square inch. It has always seemed to the writer that Professor Orton's adduced argument here fell short of a demonstration. Even admitting that the Trenton rock is continuously porous under cover from Ohio and Indiana Gas Fields to outcrop 600 feet above sea-level in Wisconsin (a condition implicitly denied elsewhere, when he explains barrenness of Trenton rock in gas under area surrounding the 'gas belt' by the 'compactness of the rock'), it would still be necessary to suppose that the columns of 'Trenton brine' rising to 600 feet above sea-level in the wells, were balanced by a corresponding body of water of like specific gravity saturating rock up to the very limit of outcrop. Such an explanation calls for the saturation of Wisconsin surface Trenton with Ohio and Indiana Trenton brine. Further, it would appear that the argument is specious that would infer hydrostatic character of cause from similarity of 'observed' pressure in wells to that calculated for them from the height to which salt water rises in neighboring abandoned wells. Of course this would be so, no matter what the nature of the cause which produced the pressure. As well argue that the pressure of the atmosphere is 'hydrostatic' in origin, because it holds up a column of water a certain height between sucks in a pump.

In view of the objections above mentioned, may it not be necessary to revive the much derided theory of 'Rock pressure'—for which the term 'lithopiestic' is proposed? In the light of facts brought out in connection with the development of the petroleum industry in recent years, many of the objections urged against this theory no longer obtain. An examination of 'bituminous sandrock' from deposits which are nothing more than old petroliferous beds formerly deeply covered by overlying strata, but now exposed by denudation and with contents oxidized, shows that the bitumen takes the place of cement in other sandstones. In other words, it was accumulated before the rocks were consolidated, or (in accordance with the 'anticlinal theory') its accumulation accompanied their consolidation. In this condition the rocks were compressible, and with them their gaseous and fluid contents. Such compression could be the result both of weight of overlying rocks and lateral pressure—the latter the same which produced the anticlinal and synclinal folds permitting of a separation of the contents in accordance with their specific gravities. When a body of strata is thrown into gentle folds without fracture, some of the beds must almost certainly undergo compression. It would appear that a bed of bituminous shale, for instance, in contact with a bed of porous, but perhaps non-compressible, sandstone or limestone, would have some of its gaseous and fluid contents driven into the interstices of such rock and held there under pressure. Such pressure would become manifest whenever the rock was penetrated by the drill.

There are a number of phenomena connected with artesian and gas wells which are probably better in accord with the 'lithopiestic' than the 'hydrostatic' theory. One of these is the sensitiveness of pressure to tremors and movements of the earth.

One experiment suggests itself that would probably determine whether this pressure is in the main 'hydrostatic' or not. If all abandoned cased wells in a district can be filled up to the top of the casing or higher with surface water, which water will remain at that level, the pressure which held the original salt water to a certain level in the well could not be hydrostatic exclusively.

The contention here is not that none of the pressure is hydrostatic (doubtless water is mainly the medium through which it is communicated), but that for certain deep artesians and all high pressure gas wells the ultimate source of the pressure is mainly lithopiestic.

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