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be acid. At greater depth it will be alkaline. During the next wet season fresh water will raise the level of the water table, the resulting solutions will descend and a zone which has previously been alkaline will become acid by reason of the encroachment of the overlying acid waters. After longer contact with ores and rocks, however, the water again will become alkaline. It is in this zone of alternating alkaline and acid conditions where many of the changes take place in the enrichment of copper and silver ores. It is practically impossible to make synthetically under natural conditions the compounds of the silver-antimony-arsenic sulphides without recognition of these changes. By varying acidity and alkalinity it is easy, however, to form such compounds even in cold solutions in short periods. It seems to me that the oscillations of the water table have not yet been given the attention they deserve in classifications which have been proposed for underground waters.

W. H. EMMONS.

THE GEOLOGIST IN WAR TIME—GEOLOGY ON THE WESTERN FRONT.

Sir: The practical applications of the general principles of geology in the Great War have been described by Professor J. S. Ames, of Johns Hopkins University, who was sent abroad last spring by the National Research Council as chairman of a committee of six to investigate the application of science to war, as illustrated on the western front. Three paragraphs from his article "Science at the Front," *Atlantic Monthly,* January, 1918, will be of interest to geologists.

> Take geology. I had heard that geologists were attached to the Staff; but I had pictured them as mining engineers rather than as professors of the pure science. Imagine, then, my surprise when I found in one of the rooms at headquarters a world-famous geologist studying and marking areas on a geological map of Flanders. All this country through which the battle-line passes has been studied with care by geologists for many decades, and Belgium and France have both published sets of maps showing all the geological details. On the professor's table was a map of the district directly east of Ypres; he was coloring certain areas red and others various shades of blue. He was also marking certain points and drawing a few straight lines.

Naturally I asked what it all meant. One color meant "Here it is safe to make dug-outs"; another "Here you will strike rock"; another "Look out for quicksands"; and so forth. The points meant "Dig for water." The straight lines meant "Here you may make tunnels or burrow mines."

I saw on the walls of the room vertical sections of the country, and inquiry brought the answer that they were for the study of underground water-systems; for the rise and fall of such might interfere with tunnels and mines, and so knowledge of them is necessary. Never have I spent a more interesting hour. It was said that one reason for the great success of the British operations at the Messines Ridge, when fifty or more mines were exploded, was the skill of the geologist who planned their location; for in some cases they were so surrounded by quicksands that the Germans could not countermine. I cannot vouch for the truthfulness of this, but, personally, knowing the men concerned, I believe it.

In this connection the value of block diagrams, which show the relation of topography to geological structure, as an aid to the officer in visualizing the topography of a region in the theater of war should be pointed out. D. W. Johnson, in "Topography and Strategy in the War," has two such diagrams, both excellent, but one of which is in many respects ideal. It is a stereograph of a portion of the Paris Basin and contiguous regions to the north and shows the relation of topography to structure. A study of this diagram furnishes the student with a key to a large region and enables him to visualize the topography; escarpments, gentle slopes, position of forests, location of swamps and marshes, and other features of great military importance. Such a diagram must be generalized but its very simplicity gives the officer the structural basis of the topography, and thus enables him to interpret the minor details of topography not shown on the diagram. Well-made topographic maps and carefully constructed geological maps show everything, and more, than such a generalized diagram, but an officer seldom has the technical knowledge or the time to gather the necessary information in this way. Consequently, block diagrams which show essential topographic and structural features should be provided and it will be surprising if the great value of such diagrams for the training of officers is not appreciated by our military in the future.

HERDMAN F. CLELAND.

Sir:—The interesting paper by A. W. Lauer on "The Petrology of Reservoir Rocks and its Influence on the Accumulation of Petroleum"[1] discusses the openings in sedimentary rocks in their relation to oil segregation in a new light. Emphasis is laid upon what the author calls "induced" openings brought about by diastrophic forces, solution, etc., and the part played by "original" openings is reduced to a place of decidedly minor importance.

There are several points on which, it seems to me, the author's conclusions are open to discussion. For example, he gives as the size of capillary pores in rocks, less than .508 mm. diameter for tubular pores and less than .254 mm. cross-section for fissures. These figures are correct for water but the fact that the maximum size of opening in which capillary will affect the average oil is considerably smaller—.2 mm. diameter for tubes and .1 mm. cross-section for fissures—is not stated. This is an important point for the movement of oil brought about by the greater capillary force of water does not necessitate a movement of oil from pores of capillary size to pores of super-capillary size, but the movement is considered to be from pores of small dimensions to pores of larger dimensions regardless of the fact as to whether the latter are super-capillary in size or not. The interchange of water for oil in fine-grained materials, the oil moving to the coarser-grained materials even though the pores of the latter are still less than .508 mm. diameter, will take place.

Again, Lauer does not believe, apparently, that original openings in detrital rocks (with the exception of some coarse conglomerates) are ever of super-capillary size, *i. e.*, greater than .508 mm. diameter for tubes and greater than .254 mm. for fissures. But these are, as stated above, the maximum sizes for water. For average oil the sizes are in each case over 50 per cent. smaller. It is not only probable but is doubtless a fact that many porous sandstones have many openings or voids which are at least .2 mm. in diameter, the maximum capillary size for oil. If such a rock is in juxtaposition with a fine-grained rock saturated with oil and in the presence of water, there is bound to be

[1] Economic Geology, Vol. XII., pp. 435–472, 1917.

an interchange even though the pores of the coarser rock may be of capillary size for water.

Another point which suggests itself is the unreliability of basing conclusions, in so far as typical "sands" are concerned, as Lauer has done, on studies made on specimens of these "sands" which have been "blown" from "wells." In the first place consolidation in these "sands" is a very variable factor and these wholly solid pieces may not be and probably are not typical of the entire bed from which they come. Again we cannot hope to duplicate in the laboratory conditions of pressure and flow even approximating the conditions which may exist in a deeply buried stratum. It may appear impossible, looking at a specimen "blown" out of a well, that a bed of the same material saturated with oil could yield a flow and yet under the conditions existing at the well bottom, whether the specimen is typical of the bed or not, we are confronted with the fact that in many cases the flow does take place.

If "induced" openings in sandstones—we all must admit their importance in limestones—are so all-important, then why, the question may be asked, are not oil pools always located in areas where we would expect such openings to exist? "These would be prominently developed at the crests of folded areas . . ." and yet in the Pennsylvania fields the great majority of oil "pools" are not at the crests of folds but on their limbs. Perhaps the author would blanket this entire region with "induced" openings. Surface observation certainly does not contribute corroborative evidence. Except in highly folded regions, specimens of rocks taken from outcrops on the crests of anticlines certainly do not exhibit "induced" openings.

Finally, Lauer believes that a recognition of the importance of "induced" openings directly "reëstablishes" the "anticlinal" theory. In the first place the relation is not evident, especially in the Appalachian oil fields, and secondly the need of reëstablishing this theory is not apparent. The "anticlinal" theory is so firmly intrenched in the minds of oil men in general and is so little correctly understood that any paper tending to show that the movement of oil is far more complicated than the simple process of gravitational separation is welcome. Washburne's valuable paper[2] on "The Capillary Concentration of Oil and Gas," while probably by no means the final word in oil movement, at least introduced a factor that will work and which must be considered and at any rate opened a new field of thought and investigation which is proving prolific in results.

WILLIAM F. JONES.

[2] *Trans. Am. Inst. Min. Eng.*, Vol. L., pp. 829–858, 1914.