lying between these deep-seated and hence highlyheated rocks and those which now contain oil and gas are, in many places at least, great thicknesses of compact shales and other fine-grained rocks which are impervious. This is well illustrated in south-western Ohio, where the Berea Grit***, and of course the rocks lying above it, and which contain important quantities of oil or gas, have lying below a great mass of fine-grained shales, ranging in thickness from 805 feet to probably 3,000 feet. If the oil and gas could have risen from below, passing through this great depth of shales, they would have continued their ascent and been wasted at the surface long before man appeared. This specific example can be duplicated in some form in every great oil or gas field. Fortunately parts of the geological scale are impervious, for otherwise oil or gas in large quantities could not exist.

If the inorganic or chemical theory were true it would be reasonable to expect petroleum and natural gas in igneous rocks, since they have been highly heated, and hence in a condition favourable for the production of these fuels. Experience, however, has shown that neither oil nor gas is found in rocks of this kind. So far as the writer knows there is no exception to this statement.

THE ORGANIC OR GEOLOGICAL THEORIES.

These theories have only one point in common; all assign organic matter as the origin of petroleum and natural gas. Some contend that these products have been derived wholly from animal matter, others entirely from vegetable matter, and others still from both. There is likewise no general agreement as to the method by which the change has been produced. Another point of difference still is the position which the products now have when compared to that which the organic matter once occupied. Some regard them as identical; that is, the petroleum and natural gas now occupy the same rocks that the organic matter from which the fuels in question were formed once occupied, while others contend that the organic matter originally occupied a lower position than the resultant products now do. A third vrew adopts each in part; that is, one theory is correct when applied to some fields but not when applied to others.

If oil and gas have been produced from organic matter then these products or others closely related ought to be secured artificially. Much experimenting has been done along this line and with considerable success; products very closely resembling petroleum have been secured artificially from both animal and vegetable matter. But how have these products been produced in nature from organic matter? This, from the nature of the problem, is not susceptible of proof. However, there is perhaps greater uniformity of opinion than in the inorganic theories. Peckham regards petroleum to have been produced by the distillation

of animal and plant remains at low temperatures. The great reservoirs in certain States he mentions were, he thought, produced in rocks lying much below those which now contain them. Phillips assigns a vegetable origin to petroleum, claiming that the change has taken place under water, and hence in the absence of air. The first changes were relatively rapid, and the later one, which is directly responsible for the petroleum, much slower, Newberry, in an elaborate theory to explain the origin of oil and gas in the Appalachian field, makes the source the plant remains in the great shales lying in the Lower Carboniferous and Upper Devonian formations, the products rising to the horizon where now found. Dr. Orton****, who has written elaborately on the subject, considered both petroleum and natural gas to have been derived from organic matter, animals in some cases, plants in others. Dr. C. B. Morrey, Professor of Bacteriology in the Ohio State University, has furnished a radically different theory, namely, that petroleum of the Pennsylvania type and gas in simithe mud of lar situations were found in which shales were composed, from the time the mud was first deposited and by the decomposing action of bacteria on the organic matter therein, the decomposition continuing until all the organic matter was broken up into compounds no longer capable of being attacked-the hydro-carbons among others-or until the bacteria were killed by an accumulation of their own products; or the decomposition could also have been stopped by a drying out of the shales, the presence of a certain amount of water being necessary for bacterial growth.

But were the fuels in question derived from organic matter which was once imbedded in the same rocks that now contain the oil and gas, or were the latter formed from organic matter which was deposited originally in rocks lying beneath those now containing these substances? There are two different views on this matter, but the majority seems to favour the latter one. Dr. Orton regarded the oil and gas in the Trenton Limestone to have been formed from animal matter which was entombed in that formation. However, when the remaining oil and gas rocks are examined, the conclusions reached are not so positive. Thus the great gas wells in the central part of the State are obtained in a thin stratum of sandstone of Clinton age.

GEOLOGICAL CONDITIONS UNDER WHICH OIL AND GAS ARE FOUND.

There are three conditions which have been strongly advocated by geologists:

I. A porous rock to contain the oil or gas.

2. An impervious cover.

3. Geological structure of the rocks which will permit the accumulation of oil and gas from relatively large areas into smaller ones.

All agree as to the necessity of a reservoir-rock. The one essential of this is porosity. Very fine

****See Geology of Ohio, Vol. VI., Economic Geology.

^{***}Berea Grit (Lower Carboniferous) is the most extensive sandstone of the State of Ohio. Its area above and below drainage is about 15,000 square miles, or more than one-third of the area of the State.