

particular strata which were originally shales containing vegetable remains which have undergone "a special mineralization, producing a bituminous matter instead of coal or lignite, and not attributable to heat, nor of the nature of a distillation, but due to chemical reaction at the ordinary temperature and under the normal conditions of climate." He describes, also, wood partially converted into bitumen, when removed by solution, woody fibre remains.

The theory of the genesis of coal oil is, however, far from being cleared up by such facts. It is true that the oil is not found in immediate contact with coal beds made of land or fresh-water plants; but on the other hand, coal oil regions are geographically connected with coal bed regions, whether of devonian, carboniferous, oolitic, or tertiary age. Coal beds are said to underlie the Rangoon oil wells. Tertiary lignites abound in Trinidad, Venezuela, Lombardy, and middle Asia. The lower devonian horizon of the Canada black slate oil region yields coal beds in Pennsylvania. The structural difficulties attending the solution of the problem remain.

Fissures are filled with oil, and gas, and salt water, and different wells strike them at different depths. The oil-bearing sand rocks seem charged from top to bottom with gas and blow off from every fissure as it is passed through by the auger. Whence comes this gas, if not by subterranean distillation? It is impossible to postulate the gas first and oil afterwards; for that order would require the generation of pressure sufficient afterwards, and the oil would be in the condition of a mechanically explosive fluid. The gas must be a subsequent expansion of the oil, as it is in the case of coal-mine fire-damp. Whence, then, comes the oil, and why has it collected in reservoirs? How are such reservoirs preserved, and what is their extent? It is easy, after these questions have been answered, to describe the mechanical propulsion of the oil to the surface, partly by gravity and partly by the pressure of the gas it has itself generated, through natural fissures producing natural oil springs, or through artificial auger holes. The intermittent action of most of the flowing and spouting wells is like that of the Iceland geysers, where steam is the motive power. The oil men of the Mahoning valley say that more gas is blown off in winter than in summer.

At the Edenburg well, above referred to, the blast of gas is sometimes violent enough to stop the pumping engine for half an hour at time. Mr. Clark reports a periodicity or daily maximum in the paroxysms. He noticed for several weeks that they recurred with singular regularity a few minutes after eight o'clock in the evening, when the engine was forced to stop for twenty minutes or half an hour.

In the almost unchanged horizontal posture of the western coal measures no considerable fracturing or fissuring took place. Faults of all kinds are uncommon and very small when they exist at all. The rise of stratification from the Alleghany river towards Lake Erie is a fraction of one degree. The original contents of the rocks have therefore been preserved. Not so with the anthracite basins on the south-eastern side of the great coal area. Crushed and upturned and overturned, contorted

and fractured in every part, this part of the earth's crust has been dried and hardened, and exposed to chemical action from the superincumbent drainage waters, until its various formations (the coal beds included in the number) have been metamorphosed and partially re-crystallized. The oils which they contained have been lost by dissolution and evaporation. The bituminous coals have become anthracites, and the last oil spring on the headwaters of the Lehigh, the Schuylkill, the Juniata, the Potomac, or the New river ceased to flow many millions of years ago. In the West, on the contrary, in equally ancient, nay, in identically the same rocks, the Petroleum still remains, having had no outlet; always hermetically sealed and under pressure. It remains partly condensed in coal beds and black shales, partly distributed through the sand rocks and limestones, and partly filling up the joints which the shrinking of ages has produced. Possibly a small portion of it may be held in caverns through the more soluble limestone strata. Especially important are the water bearing horizons.

The vertical cleavage planes and few down-throw fissures which exist play but a subordinate role to these. Rain waters percolate from every hill surface and valley bed, sidewise and downwards, leeching every permeable stratum that will give up its salt and oily contents. Along the outcrops of every coal bed issue innumerable springs of painted water. At the base of every great sandrock, and on the top of the clayey deposits next below it, collect the mixed proceeds of the drainage in a standing sheet of oily brine. Capillary attraction and hydrostatic pressure perpetually re-enforce the reservoir. The weight of rock on top and the pressure of disengaged oil-gas sends its filaments forward and upward by every secret crack to the surface again, holding it in every part ready for an explosive rush into the air when an artificial outlet is provided. If there be no fissure in the locality, the oil wells descend to the sheet of water at about the same depth. Where fissures intercept them they are of various depths and fortune, for a well may pass a fissure where its walls are polished and tight together. A well may also pass the water sheet where some change in the porosity of the rocks above and below has taken place to oppose a like obstruction. In some parts of the western coal field, the dip is as high as five degrees, and the basins from five to ten miles wide. Sharp flexures make local dips of thirty degrees or more, and a central sub-anticlinal is sure to subdivide the basin. In the secondary basins thus formed, the wells are more perfectly artesian as to the salt water; but it is upon the subdividing anticlinals that the gas and oil collect. In such regions it is asserted that all the blowing and many of the spouting wells are ranged along the summits of such anticlinals. In the case of some of the old gas-blowing salt wells, their actions demonstrate that they have been bored past one gas-bearing stratum to another deeper salt water stratum; for when the water is allowed to rise in the auger hole, by stopping the pumps awhile, then the gas and oil no longer come up, the brine stopping their issue. In the case of neighboring wells of different depths striking a slanting fissure, the one which strikes it