

give evidence of animal life. The reservoir rocks that favor accumulation are sandstones and porous limestones. The impervious stratum that prevents escape is nearly always a clay or shale and generally a wet one. The following conditions, while not essential, favor the storing of the hydrocarbons; first, the occurrence of low anticlinal arches or domes; and second, the saturation of the surrounding rocks with water. Surface indications, though not essential for sane prospecting, give confidence and sometimes aid to the operator.

Application of principles to Western fields.—Before applying the above principles to Western fields, it might be well to point out that there are places in which the essential conditions and many of the favorable ones exist, which do not yield oil or gas. In other words, there are areas which are geologically possible and some even geologically probable, which do not yield oil and less often gas.

For the purpose of applying the principles underlying the occurrence of petroleum and natural gas as outlined above, to conditions in Western Canada, a brief outline will follow, of the geology of a wide belt lying east of the Rocky Mountains and extending from the United States on the south to the Arctic ocean on the north.

The accompanying table of formations, compiled from the reports of the Geological Survey of Canada, include formations recognized over considerable areas and those of interest in connection with the hydrocarbons.

Tertiary.—Paskapoo. Exposed over large areas in Western Alberta. Light colored sandstones with bluish and greenish shales. In the foot-hills there is a thickness of over 5,000 ft., but the formation thins out on the plains. In the southern and western fields of United States, there are evidences of oil in rocks of similar age. Fossils indicate a fresh water origin.

Cretaceous.—Edmonton. St. Mary river beds of southern Alberta. Large areas exposed in central and western Alberta. A series of light colored clays and sands containing coal seams and forming a brackish water transition formation between the fresh water Paskapoo and the marine Bearpaw series. Thickness is at least 700 ft. in central Alberta. North and west of Edmonton are surface indications of oil. The Edmonton and Paskapoo beds in this area represent the transition period between the Cretaceous and Tertiary, known as the Laramie.

Bearpaw. (Pierre-Foxhill). Exposed in large areas in the foot-hills, in central and eastern Alberta, in southern Saskatchewan and southwestern Manitoba. Mostly marine, but in places, brackish and fresh water formation. Variable thickness up to and over 1,000 ft. No authentic indications of oil.

Belly River. (Judith River). Sandstone and shale formation resembling the Edmonton. Thickness up to and over 1,000 ft. Similar age to Dunvegan beds in the Peace River area. Found in the foot-hills and over a large part of southeastern Alberta. Indications of oil, and gas have been found in several places in Alberta in this series.

Niobrara-Benton. Shales, some calcareous and many dark colored and sandstones. From a few hundred feet in thickness on the plains to several hundred in the foot-hills. Marine origin. Oil is found in rocks of this age in the Western States and there are indications in Canada. Besides the occurrence in the foot-hills, there is a large area exposed in the Athabaska River country, north of Edmonton.

Dakota. Fresh water sandstones in southern Alberta. Marine sands in northern Alberta. Gas wells between Bow Island and Medicine Hat have good flow and strong pressure. Farther north on the Athabaska country, the Dakota seems to have served as a reservoir rock for oil coming from underlying Devonian limestones.

Kootanie. Sandstones and shales found in the Rocky Mountains and their foot-hills. Found in Dakota and Montana on the plains, so will likely be found to underlie the younger formations over large areas of the Canadian plains.

Jurassic.—Ferne Shale. Black and brownish shales of marine origin, found in the mountains and foot-hills and varying in thickness from 1,600 ft. in the former to 200 ft. in the latter. They are traceable north to the Athabaska. It is probable that they may continue for some distance eastwards from the foot-hills as a gradually thinning formation.

Triassic.—Upper Banff Shale. Red, sandy shales, capped by a bed of limestone. Traced north to the Brazeau and probably correlated with the Triassic of the upper Peace and Pine river areas. Marine origin.

Carboniferous.—Thick beds of limestones occur in the Rocky Mountains and may continue eastward into the plains as a thinner formation.

Devonian.—Like the Carboniferous, they occur in the mountains and probably continue eastward as a hidden formation. Limestones of this age are found over large areas from northern Alberta to the Arctic. Here, they are of special interest as being the probable source of the oil that impregnated the tar sands.

The country lying to the north and northwest of Alberta has been only slightly studied by geologists, and very few of the formations found there have been assigned to their definite horizons. It is well known, however, that large areas of Tertiary, Cretaceous and Devonian and probably Jurassic-Triassic rocks are exposed in this wide belt.

The following list of the probable succession of events, compiled from the areal geology, will give an idea of the structural geology:

1. A subsidence of probably the whole of the area in Canada between the Cordilleras and eastern Manitoba as far north as the lower Mackenzie basin, throughout Palaeozoic times, is evidenced by the exposures of a fairly complete series of Palaeozoic formations in Manitoba and in the Rocky Mountains, and by the extensive occurrence of Devonian limestone in the Mackenzie basin.

2. At the close of the Palaeozoic, there was probably a fairly general emergence, as submergence during early Mesozoic times is represented only by a belt of Jura-Triassic rocks appearing in the Rocky Mountains and widening to the north.

3. During Cretaceous times, there was an oscillation of the crust, providing alternating land, shallow water and marine formations, and too complicated to allow even a brief outline of the succession of events.

4. Oscillation of the crust continued during the Laramie and was followed by a general upward movement of the Rocky Mountain area.

5. Tertiary lakes probably covered considerable areas east of the mountains.

6. Elevation, erosion and later glaciation.

It will be of interest to know: the thickness in different localities of the several Cretaceous formations east of the mountains; to what extent the Palaeozoic and early Mesozoic underlie the Cretaceous on the plains; and whether the structures of the older formations below, conform with the newer ones above.