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PART III-ABSTRACTS OF TECHNICAL PAPERS, 1959-60

SOME PRINCIPLES OF PETROLEUM OCCURRENCE

LEWIS G. WEEKS

Though hydrocarbons occur in almost all sediments, the quantities present in different types of sedimentary basin situations and geologic ages vary extremely widely. Individual accumulations range from very minor, noncommercial quantities up to billions, even hundreds of billions of barrels of oil, or many trillions of cubic feet of gas.

Though surface indications signal the presence of petroleum, their relative abundance is not a quantitative index of of the basin's prospects.

Petroleum is of organic origin. Hydrocarbons similiar to those in crude oil have been found to be widely present in recent sediments. Carbon 14 studies show that these hydrocarbons are of the same age as the sediments in which they occur. Indeed, recent facts suggest that much of our petroleum may actually have been formed within the living organism and deposited with the sediments.

The primary basic control of oil occurrence was the deposition environment. The only direct indicator of past basin environments is the sediment facies, and the environment of similar facies in modern basins. In the latter, the various elements that determine environment, and even the initial steps in the history of petroleum development and migration, can actually be observed and measured.

Basin form, manner of subsidence, and rate of deposition play a predominant role in determining the environments and the physical conditions that control oil occurrence. Broadly illustrative is the fact that the major part of the world's petroleum occurs clustered closely around or alongside of basin sinks or troughs of more rapid subsidence relative to deposition. Petroleum occurs most abundantly in reservoir facies of timely traps that lay closely adjacent to source facies depressions. Examples of typical source and reservoir facies and their environments of deposition are indicated. One of the best indicators of the facies is the fauna, or even the absence of fauna.

From what has been said, it follows that timeliness of trap is a cardinal requisite for petroleum occurrence. The facts of oil occurrence worldwide show clearly that a trap which was not formed very early, in other words, a trap which was not in existence at the time of or very shortly following deposition and hence was not present at the time of the primary oil migration, normally carries very little or no commercial petroleum. The amount of secondary (late) migration is minor. It accounts at best for but a minor percentage of accumulated petroleum, though it is responsible for local readjustments under certain favorable conditions. Many facts are given to show that oil migrates early, and the importance of timeliness of traps is stressed.

The importance of a relatively rapid rate of deposition derives from the fact that the oxidation reduction potential and, in consequence, bacterial oxidation, whether aerobic or anaerobic, decreases very rapidly with burial. Actually, as the hydrocarbons themselves are the most vulnerable constituents

of the organic matter, the total volume of hydrocarbons preserved in rapidly deposited flank sediments of relatively low percentage total organic content may be very much greater than in the slowly deposited deep basin muds with their characteristically higher percentage organic content.

Other factors favorable to petroleum occurrence, in addition to an adequate rate of deposition, are: variability in rate of deposition laterally; lateral lenticularity, rather than uniformity of deposition across the basin; a favorable relation of reservoir to source facies; a favorable physical relationship, each to the other, of reservoir and source facies; and a good degree of sorting or screening of muds from the sands.

The foregoing and other factors outlined are fundamental reasons for the occurrence of petroleum in trends.

Many of the conditions basically favorable for petroleum occurrence existed in sediments of deposition basins that were not truly marine, but which were of semimarine, brackish, or even of a more restricted deposition environment. Many such basin situations have resulted in minor to large accumulations of hydrocarbons.

In many basins of the world containing minor to vast quantities of petroleum, evaporites have played a prominent role in effecting the occurrence. In many cases evaporites are very significant as indicators of the general favorability of the basin conditions for petroleum. In the first instance, evaporites, because of their relative plasticity under pressure, have greatly facilitated timely structure development. In other cases, because of exceptionable impermeability, they have formed the caprock or the trap seal for minor to huge oil occurrences. They are also an indicator that prior to basin closure adequate for evaporite deposition, silled or otherwise favorable conditions probably existed for hydrocarbon preservation on a moderate to vast scale.

In addition to the readily recognizable unconformities and disconformities in sediments, so-called conformable sediments are replete with a vast number of deposition breaks. These represent far more time than does the actual deposition. All forms of deposition breaks, from the most minor to major unconformities, play a predominantly controlling role in petroleum migration and accumulation.

The facts of oil occurrence worldwide confirm conclusions suggested to this point, that petroleum occurrences normally derive in nearly all cases from a contemporaneous, penecontemporaneous or overlapping source.

The relative distance of migration, whether long or short, depends on various circumstances that are discussed. Intimate interrelationship of source and reservoir facies exist in most cases. This is particularly true of prolific trends or occurrences. Such interrelationships result from the common manner in which basins subside, as explained, and they indicate that very long migration has not been the usual thing.

The usual pattern of oil occurrence in a basin is one of increasing A.P.I. gravity basinward. Numerous reasons that have been suggested by others or by the author for this common distribution are outlined.

The role of faults in oil migration and accumulation is discussed and exemplified. The facts of oil occurrence show that faults act far more commonly as barriers to, rather than as conduits for petroleum migration. They also show

that a timely fault so disposed as to form a trap is about as certain to cause an oil accumulation as any other type of timely trap.

As hydrocarbons are present in practically all sediments, geochemical anomalies are believed more likely to be an indicator of some kind of structure of the near surface sediments than they are of petroleum accumulation at depth. For instance, they may indicate only a change of dip, a minor subsidence break, or a sedimentary change of minor magnitude within these sediments. Some of the reasons for this view are given.