Chapter 5
From Kerogen to Petroleum

As sedimentation and subsidence continue, temperature and pressure increase. In this changing physical environment, the structure of the immature kerogen is no longer in equilibrium with its surroundings. Rearrangements will progressively take place to reach a higher, and thus more stable, degree of ordering. The steric hindrances for higher ordering have to be eliminated. They are, for instance, nonplanar cycles (e.g., saturated cycles) and linkages with or without heteroatoms, preventing the cyclic nuclei from a parallel arrangement.

This constant adjustment of kerogen to increasing temperature and pressure results in a progressive elimination of functional groups and of the linkages between nuclei (including carbon chains). A wide range of compounds is formed, including medium to low molecular weight hydrocarbons, carbon dioxide, water, hydrogen sulfide, etc. Therefore, the petroleum generation seems to be a necessary consequence of the drive of kerogen to adjust to its new surroundings by gaining a higher degree of order with increasing overburden.

In unmetamorphosed sedimentary basins this process of rearrangement is not carried to the end. The level of regional metamorphism is needed to reach the graphite stage, which is the stable configuration under high temperature and pressure.

5.1 Diagenesis, Catagenesis and Metagenesis of Kerogen

Kerogen is a polycondensed structure formed under the mild temperature and pressure conditions of young sediments and metastable under these conditions. Therefore, its characteristics seem to remain rather constant, even in ancient sediments, as long as they are not buried deeply. A typical example is provided by the lower Carboniferous lignites of Moscow. Although they are about 300 million years old, their carbonization rank is still very low, because they have never been buried deeper than 200 m (Karweil, 1956). In most cases, however, as sedimentation and subsidence proceed, kerogen is subjected to a progressive increase of temperature and pressure. It is no longer stable under the new conditions. Rearrangements occur during the successive stages of diagenesis, catagenesis, and metagenesis toward thermodynamic equilibrium (Fig. II.5.1).

Such evolution has been studied in detail in various rock sequences, and particularly in the Devonian and Cretaceous of Western Canada (McIver, 1967), the Tertiary of Louisiana (Laplante, 1974), the Lower Toarcian shales of the
5.1 Diagenesis, Catagenesis and Metagenesis of Kerogen

Fig. II.5.1. General scheme of kerogen evolution from diagenesis to metagenesis in the van Krevelen diagram. Approximate values of vitrinite reflectance are shown for comparison.