

and the whole of them make together a thickness of 2125 feet. They are separated by masses of shale, varying in thickness from 10 to 50 feet. The intercalated coal-beds, sixteen in number, are generally from 1 to 5 feet thick, one of them, which has two or three layers of clay interposed, attaining 9 feet.* At other points in the same coal-field the shales predominate over the sandstones. The horizontal extent of some seams of coal is much greater than that of others, but they all present one characteristic feature, in having, each of them, what is called its *underclay*. These underclays, coextensive with every layer of coal, consist of arenaceous shale, sometimes called fire-stone, because it can be made into bricks which stand the fire of a furnace. They vary in thickness from 6 inches to more than 10 feet; and Mr. Logan first announced to the scientific world in 1841 that they were regarded by the colliers in South Wales as an essential accompaniment of each of the one hundred seams of coal met with in their coal-field. They are said to form the *floor* on which the coal rests; and some of them have a slight admixture of carbonaceous matter, while others are quite blackened by it.

All of them, as Mr. Logan pointed out, are characterized by inclosing a peculiar species of fossil vegetable called *Stigmaria*, to the exclusion of other plants. It was also observed that, while in the overlying shales or "roof" of the coal, ferns and trunks of trees abound without any *Stigmaria*, and are flattened and compressed, those singular plants of the underclay very often retain their natural forms, branching freely, and sending out their slender leaf-like rootlets, formerly thought to be leaves, through the mud in all directions. Several species of *Stigmaria* had long been known to botanists, and described by them, before their position under each seam of coal was pointed out, and before their true nature as the roots of trees was recognized. It was conjectured that they might be aquatic, perhaps floating plants, which sometimes extended their branches and leaves freely in fluid mud, and which were finally enveloped in the same mud.

CARBONIFEROUS FLORA.

These statements will suffice to convince the reader that we cannot arrive at a satisfactory theory of the origin of coal until we understand the true nature of *Stigmaria*; and in order to explain what is now known of this plant, and of others which have contributed by their decay to produce coal, it will be necessary to offer a brief preliminary sketch of the whole carboniferous flora, an assemblage of fossil plants with which we are better acquainted than with any other which flourished antecedently to the tertiary epoch. It should also be remarked that Göppert has ascertained that the remains of every family of plants scattered through the coal-measures are sometimes met with in the pure coal itself, a fact which adds greatly to the geological interest attached to this flora.

Ferns.—The number of species of carboniferous plants hitherto described amounts, according to M. Ad. Brongniart, to about 500. These

* Memoirs of Geol. Survey, vol. i. p. 195.