sandstones preclude such an origin. It must be admitted, however, that the formation of the different kinds of clay—red, white, drab, blue, and black—found in the mines of the region, presents many unsolved problems. Information is lacking in regard to the original character of the beds that gave rise to these varieties of clay. At the surface these strata have been thoroughly decomposed, and there are no deep excavations to furnish the desired data.

The depth to which the clay and the brown ores extend, nearly 200 feet in several places, indicates free underground drainage. Where the rocks have been decomposed to so great depths the structural features, such as the fracture zones previously mentioned, openings between bedding surfaces caused by the uplifting of the strata, and the alteration of limestones and shales or sandstones and shales, favored the collection of the surface waters into channels and produced the localization of weathering described. The depth to which the limonite and the clays extend implies that outlets for subterranean drainage existed at equivalent or lower elevations.

As the decomposition and removal by solution of portions of the strata proceeded, the ground gradually settled downward, producing sink holes, which would still further increase the volume of percolating water through the collection of more of the rain water, which formerly reached the surface streams. When the ice sheet advanced over the limestone valleys these depressed areas were largely obliterated by the deposition of glacial debris, which is generally thicker over the iron-ore deposits than elsewhere.

The settling of the clay owing to the shrinkage of the rocks also broke the particles of iron ore, producing the wash ore described above.

**Method of Working**

Most of the limonite mines of the limestone region were worked by open cuts, especially in the early stages, and many of the mines of the Cambrian sandstones also were worked in that way. The great quantity of clay and the few ledges of hard rocks associated with the ore at first favored open-cut work, but as the excavations increased in depth the loose materials tended to slide into the pits after heavy rains, and shaft mining replaced the former method. In numerous places shafts have been sunk in or near old pits. Where the mines were on steep slopes, as were many of those in the Cambrian sandstones, the deep cover of hillside wash made shaft mining necessary from the beginning.

In open-cut mining the body of ore, which occurred in a more or less veinlike form, was followed, but mining was not restricted to these bodies. Throughout the mass of clay considerable wash and lump ore would be found, sufficient to justify practically everything being taken out and run through the washers for a considerable distance on both sides of the body of concentrated ore. In this way, in some places, several acres were worked over. When a pit was first opened, horses and carts were used to haul the ore to the washer, but as the mine became deeper, inclined tracks were laid, up which the ore was hauled in small cars. In the open-cut mines of the limestone regions the limestone floor was very irregular. The rock came within twenty-five feet of the surface in many places, but elsewhere it was not