

was in place excessively hard, almost flinty in texture, but when exposed to the weather it soon crumbled down into sandy mud. Here and there it was impregnated with iron pyrites and contained large blocks of black shales and other sedimentary inclusions; or, again, it was interspersed with small drusy cavities or veins of pitch or solid paraffin." Describing the beds on the shore of the River Forth, below Hopetoun House, Mr. Cadell says:—(1) "These underlying beds are traversed by a dyke of white or yellowish trap with cavities full of bitumen, such as have been noted in the Broxburn district."

Mr. Cadell, I might add, advances the opinion that in the above cited instances of pitch or solid paraffin in igneous rocks, they "are derived no doubt from the distillation of the hydrocarbons in the shale;" but this, I submit, is an impossibility, and, even more, a direct contradiction, as it cannot be imagined that a hot igneous rock, which would distill or drive away the hydrocarbon from a shale, would drive it away into numerous cavities of itself. Then again, if this distillation had taken place, in the case above cited of the volcanic neck, the bitumen of the black shale fragments in the neck would also be driven away. Therefore, the instances cited by Mr. Cadell cannot be regarded otherwise than as most direct evidences that the origin of the oil of the shales is most intimately connected with the very volcanic rocks in the cavities of which solid remnants of the oil are still left as witnesses. One, indeed, has only to look at the numerous red spots on Mr. Cadell's map, accompanying his paper, and representing the volcanic rocks and intrusive basalts evidently younger than the oil-shale series, to, at once, understand that this oil district, in which the oil-shale quarrying is going on to-day, was, subsequently to the deposition of the shales, subjected to intense vulcanism. During and after this great period of volcanic activity, the whole district must have been for a long time permeated by solfataric emanations coming up through the numerous faults, also shown on the map, and many other minor fissures. No doubt these emanations were composed, as we will see all volcanic emanations are, of chloride, including ammonium chloride, hydrocarbons and sulphuretted hydrogen vapours and gases, and this is clearly how these shales got im-

(1) *Loc. Cit.*, p. 359.