

XXVIII. *Analysis of one hundred parts of a dark Bituminous Limestone, from the Parish of Whiteford in Flintshire, North Wales.*

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THE superiority which has been observed in the architecture of the ancient *Greeks* and *Romans*, may in some measure be ascribed to the materials used in the construction of their edifices. This remark is especially applicable to the works of the *Romans*; because a very principal part of the materials of their architecture consisted of substances that were in their nature artificial. Their *aqueducts*, *walls*, and *foundations*, often consisted of *bricks* and *mortar*; and in the making of *mortar*, by the judicious use of the *pulvis Puteolanus*, a *cement* was prepared which had the property of becoming indurated under water, in such a remarkable manner, that, in many instances, it acquired a greater degree of hardness than the substances themselves exhibit, which this *cement* was intended to hold together. To this property are owing the specimens of *polished mortar*, which exist in the cabinets of antiquaries, derived from ruins upon the coast of *Baia*, of *Putéoli*, and of *Naples*, and wherever else the *pulvis Puteolanus* was used in the fabrication of mortar, which has subsequently been exposed to the action of

water. "*Puteolanus pulvis*," says SENECA,* "*si aquam attigit, Saxum est.*"—It was a property so well known to the ancients, that the ashes of *Putéoli* were exported to very distant parts of the Roman Empire, to be used in the preparation of *mortar* for all public works, such as moles, bridges, and ramparts, situate in rivers, lakes, or in bays, and upon the borders of the sea.† The excavations carried on in search of it, caused the spacious caverns and extensive subterraneous galleries, afterwards used as catacombs, in the neighbourhood of *Naples* and of *Rome*; ‡ and the same arenaceous substance has sometimes been brought even into *Great Britain*, to be used in the fabrication of *mortar*, both in ancient and in modern times. It may therefore be considered as a discovery of some importance, that we possess, in this country, a species of *limestone* which, when used for purposes of extracting lime, and in the preparation of *mortar*, is capable of communicating to the cement all the properties of the *pulvis Puteolanus*.

This species of *limestone* is found in *North Wales*, in the parish of *Whiteford*, in *Flintshire*. Some specimens of it were sent to me by my friend *David Pennant*, Esq. son of the celebrated naturalist of the same name. Its *specific gravity*, estimated in pump water, at a temperature of 50° of Farenheit, equals 2.670. It is of a dark brown colour, and, when breathed upon, it exhales an earthy odour, denoting the presence of *iron oxide*, in combination with *alumine*; but its colour is owing to *bitumen*, rather than to *iron*, as will appear by the following analysis, undertaken at the request of Mr. *Pennant*, for ascertaining the chemical constituents of this *limestone*.

* *Natur. Quæst.* Lib. 3. Cap. 20. See also *Pliny. Hist. Nat.* Lib. 35. Cap. 13.

† The *pulvis Puteolanus* was also used by the ancients in constructing the streets of *Rome*, and in all the great roads of the empire. See *Winkelmann, Hist. de l'Art*, tom. 2, p. 553.

‡ *Winkelmann, Observ. sur L'Architect. des Anciens, &c. ubi supra.*

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1. One hundred grains being placed upon red hot iron for the expulsion of the *water of absorption*, were thereby diminished $\frac{5}{8}$ of a grain.

2. The remainder being reduced to powder in a porcelain mortar and exposed to diluted muriatic acid until all effervescence ceased, there remained an insoluble residue of the original dark colour of the limestone, which when carefully washed and dried, weighed 10 grains; allowing therefore for the weight of the *carbonic acid* and *lime*, after the expulsion of the *water of absorption*, $89\frac{1}{4}$ grains.

3. The supernatant acid used in this experiment being decanted, and neutralized by the addition of an alkali, yielded no precipitate of *iron* to the tincture of galls; but the prussiate of potass threw down a blue precipitate upon which however no reliance can be placed; as it is well known that the prussiate of potass is not a satisfactory test of the presence of *iron* when this metal exists in an inconsiderable portion.

4. The ten grains of dark brown powder mentioned in No. 2, being collected, washed and dried, were exposed to the heat of a flame of a candle urged by the common blow-pipe, when combustion instantly ensued, accompanied by a lambent flame, which continued during some seconds, the powder thereby losing its colour and becoming white; attended also by a loss of weight, amounting to $\frac{2}{3}$ of a grain. Hence it is manifest that the colour is owing to *bitumen*.

5. To ascertain the proportion of *alumine* (which from its chemical combination with *silex* remained insoluble in the muriatic acid) a plan recommended by Mr. *Holme* was adopted. One hundred other grains of the same limestone were calcined in a platinum crucible, and the loss of weight owing to the expulsion of the *carbonic acid* was found to equal $40\frac{1}{8}$ grains.

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6. The calcined residue being placed in muriatic acid, a solution now took place both of the *lime* and of the *alumine*, and there remained at the bottom of the vessel only an insoluble portion of pure *silex*, in the form of a white powder, which when carefully washed and dried weighed $\frac{2}{3}$ of a grain. Deducting therefore this weight of the *silex*, from the weight of the *silex* and *alumine*, which remained in No. 4, after the combustion of the *bitumen*, the weight of the *alumine* is ascertained; which of course equals $8\frac{8}{10}$ grains.

From all the preceding observations, it is therefore evident that the constituents of this LIMESTONE are as follow :

Lime	49.	65
Carbonic acid	40.	10
Alumine	8.	80
Silex	—	60
Bitumen	—	60
Water	—	25
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And the valuable property of the *mortar* prepared from this *limestone*, is owing to the presence and proportion of *alumine*; and to its property of rapidly absorbing water.