A

COMPENDIUM,

&c. &c.

SECTION I.

CHAPTER I.

OF CALCAREOUS MINERALS, AND THE VARIOUS KINDS OF LIME THEY FURNISH.

1. Calcareous minerals are substances essentially composed of lime and carbonic acid;[a] they always dissolve, either wholly or in part, in weak acids, with a more or less brisk effervescence, and may be scratched with an iron point.

2. Limestones are sometimes pure, that is to say, wholly composed of lime and carbonic acid; at others, the lime is associated in intimate combination with silica, alumina,[b] magnesia, with quartz in grains, oxide of iron, manganese,[c] bitumen, or sulphuretted-

[a] Carbonic acid is a gas composed of one equivalent of carbon and two of oxygen: it is transparent and colourless, and incapable of supporting combustion or respiration: it combines with the alkalies, oxides, &c., forming the class of *carbonates*.—Tr.

[b] Alumina, or oxide of aluminum as it is now termed, is the substance which forms the basis of the plastic clays.—Tr.

[c] Manganese is a metal similar in appearance to iron, but rarely met with in the metallic state.—Tr.

hydrogen.[d] The presence of these substances one by one, or two and two, or three and three, &c., constitutes the various kinds of limestone, which are further subdivided into different varieties.

3. Mineralogists distinguish the argillaceous, magnesian, sandy (arénacés), ferruginous, manganesian, bituminous, fetid, &c.; and then in each of these kinds point out varieties of form and structure, which they specify under the denominations of foliated, lamellar, saccharoidal,[e] granular, compact, globular, coarse,[f] chalky, pulverulent, pseudo-morphous,[g] concretionary, nodular, ("geodiques"[h]) incrusting, &c., &c. (App. I.)

[d] Sulphuretted-hydrogen is a compound gas, containing one equivalent of sulphur, and one of hydrogen. It is liable to be extricated on the decomposition of a metallic sulphuret by water, whence it is not an uncommon natural product.—Tr.

[e] "The whitest and most esteemed (granular limestone), from its resemblance to sugar, has been termed by the French mineralogists chaux carbonatée saccharoide; but it has more generally, from its important uses in the arts, obtained the name of *Statuary Marble.*" —*Phillips's Mineralogy*, edit. 1816.

[f] "The houses of Paris are built of a large-grained and soft calcareous stone, which is incapable of polish, and is of a dingy white, grey, or yellowish-white colour. It is found in immense horizontal beds, forming the plains south of Paris. It is a very impure limestone, and furnishes when calcined a very bad lime. The use to which it is put has occasioned its receiving the familiar name of Pierre à bâtir. Haüy describes it under that of chaux carbonatée *grossière.*"—*Ibid*, p. 129.

[g] "Minerals exhibiting impressions of the forms peculiar to the crystals of other substances are said to be pseudo-morphous."—*Ibid*, p. l.

[h] "A geode is a hollow ball. At Oberstein, in Saxony, are found hollow balls of agate lined with crystals of quartz or amethyst, which are termed geodes."—*Ibid*, p. xlvi.

4. It is useful to be acquainted with this nomenclature; but that which it is of the most importance for the builder to be aware of, is, that each variety of limestone furnishes a peculiar kind of lime, distinct in colour, weight, in its avidity for water, and above all by the hardness it acquires on being mixed intimately after slaking with the earthy substances known under the names of sand, puzzuolana, &c.

5. The physical characters which serve to distinguish calcareous minerals, fail to give any certain indication of the qualities of the lime they contain. Even chemical analysis itself is mostly but an approximate mode of investigating them, in addition to its being only within the reach of those familiar with laboratory manipulation. Experience by actual trial ought to be the builder's only guide. (App. II.)

6. We readily assure ourselves that a mineral belongs to the calcareous class, by trying it, as I have already said, with an iron point, and a weak acid.[1] Having established this fact, we reduce the experimental specimens to the average size of a large walnut, and fill with them a crucible ("gazette"), or any other vessel of baked earth, pierced with holes to favour the circulation of the air: we place the whole in the middle of a pottery furnace, (a brick or lime-kiln will answer equally as well, if it is heated by the flame of a fire of wood or furze,) and at the end of its calcination (fifteen to twenty hours) we remove the material, and introduce it while still warm into large-mouthed bottles, quite dry, and which we immediately

[1] Vide Articles 1 and 23.

close hermetically. The object of this precaution is to preserve the lime in all its activity (causticity), till the moment fixed on to submit it to experiment.[k]

7. When we feel disposed to begin this experiment, we remove the lime from the bottle, and take as much in bulk as would about fill a quart measure (including voids): we put it into a cloth bag of an open material, or rather a small basket; we immerse the whole for five or six seconds only in pure water; we drain it an instant, and then empty the bag or basket into a stone or cast-iron mortar.

8. The following are the different phenomena which may ensue after this immersion:—

1st. The lime hisses, decrepitates, swells, gives out a great quantity of hot vapours, and falls to powder instantaneously, or nearly so.

2nd. The lime remains inactive for a space more or less long, not exceeding five or six minutes; after which the phenomena above described manifest themselves with energy.

3rd. The lime exhibits no alteration even after five or six minutes; a quarter of an hour even may elapse before it appears to change its state. However, it begins to smoke and crack with little or no decrepitation: the vapour formed is less abundant, and not so hot, as in the preceding case.

4th. The phenomena do not commence till an hour, and sometimes till many hours, after the exmersion.

[k] In order to make sure that the calcination is complete, it would be as well to subject a small portion of the lime to trial, by slaking it with a little water, and adding dilute muriatic acid: if sufficiently burned it ought to dissolve without effervescence.—TR.

Cracks form without decrepitation, slight fumes are given out, and but little heat is disengaged.

5th. The phenomena commence at periods very variable, but are hardly sensible; the heat developed barely manifests itself except to the touch; the pulverulence is but obscurely marked, and sometimes does not ensue at all.[1]

9. In no case is it necessary to wait till the effervescence has ceased in order to finish the slaking; as soon as the disaggregation manifests itself, we pour water into the vessel, not upon the lime, but on one side, in such a manner that it may flow freely to the bottom, whence it is sucked up by those portions of the material which are farthest advanced. We stir it at the same time with a spatula; continuing to add water if it be required, but with care not to drown the mixture. Lastly, we substitute the pestle for the spatula, and work the whole up to a stiff clayey consistency.

10. Thus prepared, the lime must be left to itself till the more sluggish portions have completed their developement. The termination of this part of the operation is indicated by the perfect cooling of the whole mass. It lasts from two to three hours, and sometimes more.

[1] If the calcined mineral (having been proved to be *calcareous* by trial with dilute acid—Articles 1 and 6) should not slake at all, or very imperfectly, it must be reduced mechanically to a perfectly impalpable powder, without the addition of water, and then dealt with as afterwards explained (Articles 11 and 12). Many of the most energetic and useful of the water-cements, such as the Yorkshire, the Harwich, and Sheppy cements, require to be treated in this manner.—Tr.

11. We now take the lime again with the pestle, and add water if it be required, in such quantity as to give us a paste as stiff as possible, yet not entirely deprived of a certain degree of ductility. Its consistency may be compared to that of clay ready to be worked up in the manufacture of pottery.

12. We then take any vessel of greater height than breadth; (a china mustard-pot, or a large drinking glass, will answer the purpose very well;) we transfer the lime to it in such quantity as to fill it up about two-thirds or three-fourths, striking the bottom of it with the palm of the hand or on a block to cause the material to settle down and spread itself on the bottom of it; we then label it carefully, and immerge the whole without delay, noting the day and hour of the immersion.

13. In studying successively during fourteen years the most remarkable limes of this kingdom treated in this manner, I have been led to arrange them in five categories, distinguished by the following denominations (App. III.):—1st, Rich limes; 2nd, Poor limes; 3rd, Limes slightly hydraulic; 4th, Hydraulic limes; 5th, Limes eminently hydraulic.

14. The *rich* limes are such as may have their volume doubled, or more, by slaking in the ordinary manner,[m] and whose consistency after many years of immersion remains still the same, or nearly the same as on the first day, and which dissolve to the last grain in pure water frequently changed.[n]

[m] Vide Article 56, and App. XXII.—Tr.

[n] Solubility in water may be used as a convenient test of the

15. The poor limes are such as have their volume but little or not at all augmented by slaking, and which, in other respects, exhibit in the water very nearly the same phenomena as the rich limes, but with this difference, that they only dissolve partially, leaving a residue of no consistency.[o]

16. The moderately hydraulic limes will *set*[p] in fifteen or twenty days after immersion, and continue to harden; but their progress becomes more and more slow, particularly after the sixth to the eighth month. After one year their consistency is about equal to that of hard soap. They dissolve also in pure water, but with great difficulty; their expansion by slaking ("foisonnement"[q]) is variable; it fre-

proper calcination of rich lime: in this case, if a little coarse sugar be melted previously in the water, it will very much increase its solvent power.—Tr.

[o] Rich limes also may leave an insoluble residue (of carbonate of lime) if either insufficiently burned, or if they should have been much exposed to the air, and become partially regenerated by the absorption of carbonic acid. Should there be any reason to suspect this, a drop or two of muriatic acid should be added to the water; when, if the residue be the carbonate of lime, formed as above explained, it will dissolve with effervescence; but if it be composed of the silicious matter of a "poor lime," it will remain insoluble.—Tr.

[p] Vide Article 20.

[q] "Lorsqu'on éteint la chaux commune avec de l'eau, á sa sortie du tour, pour la reduire en pâte, on trouve qu'elle augmente considerablement de volume; cette augmentation est telle qu'une partie de chaux vive mesurée en volume en produit quelque fois plus de trois mesurée à l'état de pâte épaisse: c'est ce qu'on appelle le foisonnement."—*General Treussart, Memoire sur les Mortiers Hydrauliques*, p. 3.

quently reaches the limits of the poor limes, without ever attaining that of the rich limes.

17. The hydraulic limes *set* after six or eight days' immersion, and continue to harden. The progress of this induration may be continued to the twelfth month, although the greatest part of the effect will be attained after six months. At this period, the hardness of the lime may be already compared with that of the very soft kinds of stone, and the water ceases to have any action on it. Their expansion by slaking is always small, like the poor limes.

18. The eminently hydraulic limes *set* from the second to the fourth day of immersion. After one month they are already very hard, and altogether insoluble. At the sixth month they appear like the absorbent calcareous stones, whose surface admits of being cut. They splinter under a blow, and present a slaty fracture. Their expansion by slaking is constantly small, like the poor limes.

19. In other respects, the rich, and poor, and hydraulic limes of all grades, may be white, grey, mouse-coloured, red, &c.[r] (App. IV.)

[r] As no reference is here made to the properties of magnesian limestones, it may be useful to describe a mode by which they may be recognised. Though capable of setting under water, they may be entirely soluble in dilute acid; but magnesia not combining with water till exposed for some time in contact with it, the mineral, if containing a large proportion of this substance, will either not slake at all, or will do so imperfectly, and will gain much less in weight than an equal quantity of calcined rich lime would do. Upon this property of magnesian limestone, Mr. Prinsep has founded a very neat and simple process for estimating the proportions of the consti-

20. We say that a lime has *set*, when it bears without depression a knitting-needle of 0.12 cent. (.047 or nearly $\frac{1}{20}$ inch) diameter, filed square at its extremity, and loaded with a weight of 0.30 kil. (about 10 ozs. 9 drs. avoirdupois weight). In this state the lime will resist the finger pushed with the mean strength of the arm, and it is incapable of altering its form without fracture.

21. The chemical examination of the minerals which supply the various kinds of lime of the preceding categories, points out, in a general way, as follows:—

1st. As furnishing the rich limes: 1st, the pure limestones, or such as contain only an admixture of from .01 to .06 of silica, alumina, magnesia, iron, &c., taken separately, or two and two, three and three, &c.; 2dly, the simple, bituminous, or fetid limestones.[5]

2nd. Such as form the poor limes: 1st, limestones associated with silica in the state of sand, magnesia, the oxides of iron and manganese, in variable proportions, but limited to .15 to .30 of the whole, whether these principles exhibit themselves one by one, two and two, three and three, or all together.

3rd. As furnishing the slightly hydraulic limes:

tuent ingredients, of which an explanation will be found in the notes. (Vide App. V.)—Tr.

[5] "Swine-stone, or stink-stone, so called from the strong fetid odour given out when scraped or rubbed, is found massive and compact, and of various shades of grey, brown, and black. By calcination it becomes white, and burns into quicklime. The offensive odour which it gives out when scraped is considered to be owing to its including sulphuretted-hydrogen: it is commonly attributed to bitumen, which does not seem to enter into the composition of swine-stone."—*Phillips's Mineralogy*, p. 130.

the limestones united with clay, magnesia, iron, and manganese, the relative proportions of which being variable, but not exceeding .08 to .12 of the whole. The oxides of iron and manganese also, being present either in the relations one to one, two and two, three and three, &c., &c., or even entirely wanting.

4th. The ingredients constituting the hydraulic limes. These are the limestones containing silica, alumina, magnesia, iron, and manganese, in variable relative proportions, amounting to not more than from fifteen to eighteen hundredths of the whole, and in other respects such, that the silica always has a predominance, no matter whether the other substances appear, as one to one, or two and two, &c., &c. The iron, manganese, and magnesia, may also be entirely wanting.

5th. The minerals affording the eminently hydraulic limes are, the limestones which contain silica, alumina, magnesia, iron, and manganese, in different relative proportions, but usually limited to from twenty to twenty-five hundredths of the whole; the silica always predominating, sometimes to the extent of forming of itself more than half the whole; and the other substances only occurring one by one, two and two, or three and three, &c. It is very seldom that we meet with them all at one time. The magnesia, and still more, the manganese, are very frequently absent.

22. In the present state of our knowledge regarding the different varieties of lime, it is impossible to say whether there exist certain determinate proportions of silica alone, or of silica and alumina, or of silica and magnesia, &c., &c., which, by their intimate association with the same quantity of calcareous