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V. *On the Boracic Acid Lagoons of Tuscany.* By JOHN BOWRING, LL.D.*

THE borax lagoons of Tuscany are entitled to a detailed description. They are unique in Europe, if not in the world; and their produce is become an article of equal importance to Great Britain as an import, and to Tuscany as an export. They are spread over a surface of about 30 miles, and exhibit from the distance columns of vapour, more or less according to the season of the year and state of the weather, which rise in large volumes among the recesses of the mountains.

As you approach the lagoons, the earth seems to pour out boiling water as if from volcanoes of various sizes, in a variety of soil, but principally of chalk and sand. The heat in the immediate adjacency is intolerable, and you are drenched by the vapour, which impregnates the atmosphere with a strong and somewhat sulphurous smell. The whole scene is one of terrible violence and confusion—the noisy outbreak of the boiling element—the rugged and agitated surface—the volumes of vapour—the impregnated atmosphere—the rush of waters—among bleak and solitary mountains.

The ground, which burns and shakes beneath your feet, is covered with beautiful crystallizations of sulphur and other minerals. Its character beneath the surface at Mount Cerbole is that of a black marl streaked with chalk, giving it, at a short distance, the appearance of variegated marble.

Formerly the place was regarded by the peasants as the entrance of hell, a superstition derived no doubt from very ancient times, for the principal of the lagoons and the neighbouring volcano still bear the name of Monte Cerboli (*Mons Cerberi*). The peasantry never passed by the spot without terror, counting their beads, and praying for the protection of the Virgin.

The borax lagoons have been brought into their present profitable action within a very few years. Scattered over an extensive district, they are become the property of an active individual, M. Larderel, to whom they are a source of wealth, more valuable perhaps, and certainly less capricious, than any mine of silver that Mexico or Peru possesses. The process of manufacture is simple, and is effected by those instruments which the localities themselves present. The soffioni, or vapours, break forth violently in different parts of the mountain recesses. They only produce boracic acid when they burst with a fierce explosion. In these spots artificial lagoons are

* From Dr. Bowring's Report on the Statistics of Tuscany.

formed by the introduction of the mountain streams. The hot vapour keeps the water perpetually in boiling ebullition; and after it has received its impregnation during twenty-four hours at the most elevated lagoon, the contents are allowed to descend to the second lagoon, where a second impregnation takes place, and then to the third, and so forth, till it reaches the lowest receptacle; and having thus passed through from six to eight lagoons, it has gathered one half per cent. of the boracic acid. It is then transferred to the reservoirs, from whence, after a few hours rest, it is conveyed to the evaporating pans, where the hot vapour concentrates the strength of the acid by passing under shallow leaden vessels from the boiling fountains above, which is quite at a heat of 80° of Reaumur*, and is discharged at a heat of 60° †. There are from ten to twenty pans, in each of which the concentration becomes greater at every descent till it passes to the crystallizing vessels, from whence it is carried to the drying rooms, where, after two or three hours, it becomes ready to be packed for exportation.

The number of establishments is nine‡. The whole amount produced varies from 7000 to 8000 pounds (of 12 ounces) per day. The produce does not appear susceptible of much extension, as the whole of the water is turned to account; the atmosphere has, however, some influence on the result. In bright and clear weather, whether in winter or summer, the vapours are less dense, but the depositions of boracic acid in the lagoons are greater. Increased vapours indicate unfavourable change of weather, and the lagoons are infallible barometers to the neighbourhood, even at a great distance, serving to regulate the proceedings of the peasantry in their agricultural pursuits.

It had been long supposed that the boracic acid was not to be found in the vapours of the lagoons; and when it is seen how small the proportion of acid must originally be, it will not be wondered at that its presence should have escaped attention. In the lowest of the lagoons, after five, six, and in some cases a greater number of impregnations, the quantity of boracic acid given out does not exceed one half per cent.: thus if the produce be estimated at 7500 pounds per day, the quantity of saturated water daily discharged is a million and a half of Tuscan pounds, or five hundred tons English.

The lagoons are ordinarily excavated by the mountaineers of Lombardy, who emigrate into Tuscany during the winter

* The boiling point.

† 167° of Fahrenheit.

‡ The principal are Monte Cerboli, Monte Rotondo, Susso, Serazzano, and Castelnovo.

season, when their native Apennines are covered with snow. They gain about one Tuscan lira per day. But the works are conducted, when in operation, by natives, all of whom are married, and who occupy houses attached to the evaporating-pans. They wear a common uniform, and their health is generally good.

A great improvement in the cultivation, and a great increase in the value, of the neighbouring soil has naturally followed the introduction of the manufacture of the boracic acid. A rise of wages has accompanied the new demand for labour; much land has been brought into cultivation by new directions given to the streams of smaller rivers. Before the boracic lakes were turned to profitable account, their fetid smell—their frightful appearance, agitating the earth around them by the ceaseless explosions of boiling water, and not less the terrors with which superstition invested them*, made the lagoons themselves to be regarded as public nuisances, and gave to the surrounding country a character which alienated all attempts at improvement.

Nor were the lagoons without real and positive dangers, for the loss of life was certain where man or beast had the misfortune to fall into any of those boiling baths. Cases frequently occurred in which cattle perished; and one chemist, of considerable eminence, met with a horrible death by being precipitated into one of the lagoons. Legs were not unfrequently lost by a false step into the smaller pits (*putizze*), where, before the foot could be withdrawn the flesh would be separated from the bone.

That these lagoons, now a source of immense revenue, should have remained for ages unproductive; that they should have been so frequently visited by scientific men, to none of whom (for ages at least) did the thought occur that they contained in them mines of wealth, is a curious phænomenon;

* So unwilling were the peasants to settle in these districts, that very extraordinary encouragements were held out to them. In the commune of Monte Cerboli any inhabitant of the town may sow and reap whatever he pleases without requiring the consent of the owner of the soil; so it frequently happens that small tracts are cultivated which are particularly favoured by water or other advantages, and all the surrounding land left untouched. As the inhabitants have the primary right, the landlord generally abandons his property to the chance cultivation of the peasant, who leaves fallow nine-tenths of the land. In the district of Riparbella the landlords and cultivators have come to a sensible agreement, by apportioning the lands in equal moieties.

Many mineral waters are in the neighbourhood of the lagoons, some of which possess medical virtues, and are visited by the Tuscans in the bathing season.

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nor is it less remarkable, that it was left for a man, whose name and occupation are wholly disassociated from science, to convert these fugitive vapours into substantial wealth.

Though to the present proprietor (the Chevalier Larderel*) the merit attaches of having given to the boracic lagoons the immense importance they now possess, a succession of adventurers had made many experiments, and had produced a considerable quantity of boracic acid, but at a cost (from the expenditure of combustible) which left little profit†. The small value that was attached to them may be seen in the fact, that the largest and most productive district of the lagoons, that of Monte Cerboli, was offered in perpetuity, so lately as 1818, at an annual ground-rent of £T. 200*l.* or 6*l.* 13*s.* 4*d.* per annum, though it now produces several thousand pounds sterling. The immense increase in their value arose from the simplest of improvements, the abandonment of the use of charcoal, and the application of the heat of the lagoons or soffioni to the evaporation of their own waters. Improvements, however, and very important ones, particularly by subjecting the waters to a succession of impregnations, had been gradually introduced by a Signor Ciaschi, and the importation of boracic acid from Tuscany into France, before 1817, had been between 7000 and 8000 pounds, of a quality gradually increasing in purity: but Ciaschi perished miserably, in consequence of falling into one of the lagoons which he himself had excavated, leaving his family in a state of extreme poverty. His death (which happened in 1816) naturally threw a damp upon adventure. The experiments were resumed in the following year, and in the midst of violent claims and controversies, M. Larderel has become the monopolist of the boracic productions of Tuscany.

With the increased production of boracic acid has arisen an increased demand, growing out of the more extensive application of it to manufacturing purposes. In about four years the quantity has been quadrupled by superior modes of extraction, and by greater care employed in the collection of the boracic vapour. In 1833 about 650,000 Tuscan pounds were obtained, in 1836 two millions and a half.

* While these sheets have been passing through the press the Grand Duke of Tuscany has conferred on M. Larderel the title of Count de Pomerance.

† Hoefer first announced the presence of boracic acid in the Maremman districts, and Mascagni in his Commentaries suggests the manufacture of borax as an object worthy of attention. Professor Gazzeri in 1807, made experiments, which however seemed to show that the quantity of boracic acid contained in the waters was too small to promise much success.

But it appears to me that the powers and riches of these extraordinary districts remain yet to be fully developed. They exhibit an immense number of mighty steam-engines, furnished by nature at no cost, and applicable to the production of an infinite variety of objects. In the progress of time this vast machinery of heat and force will probably become the moving central point of extensive manufacturing establishments. The steam, which has been so ingeniously applied to the concentration and evaporation of the boracic acid, will probably hereafter, instead of wasting itself in the air, be employed to move huge engines, which will be directed to the infinite variety of production which engages the attention of labouring and intelligent artisans; and thus, in the course of time, there can be little doubt, that these lagoons, which were fled from as objects of danger and terror by uninstructed man, will gather round them a large intelligent population, and become sources of prosperity to innumerable individuals through countless generations.

VI. *The Colours of the Atmosphere considered with reference to a previous Paper "On the Colour of Steam under certain circumstances."* By JAMES D. FORBES, Esq., F. R. SS. L. & Ed., Professor of Natural Philosophy in the University of Edinburgh.

[Continued from vol. xiv. p. 426.]

A TOTALLY different hypothesis from any of the preceding, as regards the blue of the sky, was about the same time started by Muncke. He asserts that this hue is, what the German writers call purely *subjective*, that is, an ocular deception, received by the eye on looking into vacant space*. This theory has been well discussed by Brandes, but I think he has not succeeded in explaining Muncke's fundamental experiment, which is this:—If the sky be viewed by one eye directly, and by the other through a long blackened tube, the colour in the latter case gradually seems to vanish. Now, the explanation of this optical difficulty is to be found, I conceive, in the general fact first observed by Mr. Smith†, and which I have verified in a great variety of cases, that when a white object is viewed at once by both eyes, one shaded, and the other powerfully illuminated, though its natural colour is undoubtedly white, it appears *red* to the shaded eye, and *green* to the other. The shaded eye in Muncke's experiment, therefore, superimposes a red impression (by the effect of contrast with

* Schweigger's Journal, xxx. 81; and article *Atmosphäre* in Gehler.

† Edin. Journal of Science, v. 52.