A DAY AT THE HURELT ALUM-WORKS.

In the subject of this paper were designated "A Day Underground," it would not inadequately express the main purpose in view; for the many sides of labyrinth whence the alum-ore is procured form by far the most striking and remarkable feature at the Works which are about to engage our notice. But we must somewhat enlarge the scope, so as to follow the crude ore through its manufacturing history.

It will be well at once to anticipate the question, What is Alum? And to give an answer to it. We know that, externally, alum presents the appearance of a whitish crystalline substance; but there is nothing to indicate to the eye that this substance is formed of the three singularly opposite ingredients—sulphuric acid, clay, and potash. Yet such is the case, and we here have one of the many startling facts which chemistry presents. In chemical language, alum is a " sulphate of alumina and potash" (soda or ammonia being sometimes substituted for potash); the alumina is the basis or foundation for all varieties of clay, and derives its name from being an invariable ingredient in alum. Dune and opaque as clay is known to be, even in its pure state of alumina, yet it contributes to the formation of the transparent alum so familiar to us.

These, then, being the three ingredients, the next question naturally would be—are they met with in a combined state, or do they require to be mixed artificially? Both are true; may there are even four modes of union; for in some cases crystals of alum are found ready formed in the earth—in others, the three ingredients are met with in the same ore, but not combined into alum—in others, part only of the crude ingredients are found in the ore, and require the addition of the rest—and in others, the whole are combined by artificial means. The subject of alum-making becomes thus a somewhat complex one; but we may perhaps manage to obtain a few general ideas on the matter, without involving the niceties of chemical detail.

As respects native alum, it has been found in the form of crystalline needles in some part of the Andes of South America; in the form of a kind of earthy alum, met with in another part of the same chain of mountains; in the form of long thin fibres, having soda instead of potash, and occurring in a third district of the Andes; and in the form of a mineral called alunomite, found in some parts of Germany. In all these cases the ingredients are found combined into a state nearly analogous to alum. To go to the opposite extreme, we find that in France—and also at Newcastle—the alum is wholly an artificial product, formed by mixing clay, sulphuric acid, and potash, so as to lead to chemical combination.

The intermediate modes of formation, that is, those which are in part natural and in part artificial, are of more extensive occurrence; in Italy, in Hungary, in Sweden, in Scotland, and in Yorkshire, we find examples. Various ores or earths, called alum-ore, alun-ore, slate-clay, and bauxitic slate, furnish the main material; and these, treated in various ways, yield the greater part of the alum of commerce. For instance, at Tolfa in Italy alum is made from alum-ore. Nearly four centuries ago a Genoese merchant, who had seen alum-ore in Turkey, observed that at Tolfa trees were growing such as he had seen near the alum-pits in Turkey; and he therefore conjectured that alum-ore might exist there. His conjecture was correct, and alum-works were soon established, which have existed ever since. The Tolfa alum-ore contains all the three ingredients, which, after the stone has been roasted, crumbled into powder, and boiled, combine and crystallize in the form of alum, without
the addition of any new ingredient. In Sweden the ore is pyrometallized (containing a little pyrite) with alum-slake, which, besides roasting, requires the addition of other ingredients before alum can be formed.

In Yorkshire there are three alum works. In Scotland there are two little northward of Glasgow and two a little southward. The Yorkshire works, which are near Whitby, originated thus,—Sir Thomas Chaloner, who had an estate near Whitby in the time of Charles L., found alum near the coast, and was desirous of working it; but as there was no one in England at that time who understood the art of making alum, he privately engaged men from Toledo. The Toledo works, being very profitable, hail from the first belonged to the popes, who, like monopolists generally, tried hard to preserve the whole affair to themselves; the workmen who joined Chaloner were threatened with anathemas and communications, but all in vain, for the Whitby works soon became flourishing. Chaloner afterwards had a disagreement with Charles I., respecting the works; for the king, after granting him an exclusive patent, sold half the patent to another party, as a means of procuring money; and this is said to have led to the disputes between the Chaloner and against the king, in parliament. The Whitby district, where these works are established, is a remarkable one. It consists of precipitous cliffs containing alum-slake, bordering on the sea, and stretching to a distance of about thirty miles along the coast of the German Ocean. The alum-slake is covered with boulders, sandstone, alluvial soil, and a few other matters; and when these are removed, the rock is broken piecemeal by picks and javelins, roasted, evaporated, and otherwise treated so as to yield alum.

Several details concerning alum and alum-works in other countries will enable us to understand better what meets the eye at the Hurlet works. There is a firm at Glasgow to whom three out of the four Scotch alum-works belong; viz., two near Campsie, and one near Hurlet. Either one of these will suffice to show the general character of all; and through the kindness of the proprietors we are enabled to describe the last named of the three. When the British Association met at Glasgow, in 1840, Dr. Thomson briefly alluded to these works; but rather in reference to the chemical changes that take place in the process of alum extraction and the works. The Campsie Hills are situated among the Campsie Hills, a few miles north of Glasgow; while the Hurlet works are a few miles south of Glasgow. These hills are situated in a partially exhausted coal district, for reasons which will presently appear.

A pleasant ride of half a dozen miles from Glasgow, or a railway trip to Paisley as part of the distance, brings us to an open part of the country whose green fields give but little indication of the bowing which has gone on beneath them. On arriving near the village of Hurlet, however, there are here and there streams of smoke visible, which point out the localities of certain alum, iron, and lime-works; and these indicate that the mineral riches beneath are not confined to one kind alone. The country around is undulating with gentle hills and hollows; but still there is a grassy covering which effectually conceals these underlying beds. It is not till we enter the precincts of any of the works that we find the pits which open up a communication between the world above and the world below; and even there we see little from whence a judgment might be formed of the honeycombed condition of the ground beneath; we must grope, in previsumus persons, through miles of shallow, dark, arched passages, regardless alike of water, mud, coal, and alum, before we can rightly understand the structure of the mines.

When we get within the boundary of the alum-works, we find an extensive area subdivided, occupied in part by buildings where the preparation is conducted, in part by open pits where the ore is steeped, and in part by huge heaps of earthy matter either still burning or lying useless after being exhausted. It is one consequence of the condition in which the ingredients for alum are found in the ore that a large mass of earthy refuse is separated as an incumbrance; and this refuse is accumulated in enormous piles and stone-built, until taken away to be used (we believe) for footpaths or in the formation of railroads. There is no large factory, no many-storied building with its various rooms filled with workmen; the buildings being only so far as necessary to enclose the furnaces, the boilers, the tanks, the coolers, and the other vessels required in the process; together with the water-wheels which raise the ore from the pit, and pump liquid from one vessel to another.

In such districts as this, the possession of a mine by no means implies the possession of the ground above it; the two are held by different tenants, and are leased, or may be leased, independently of each other. Nay, not only so; but if the mineral strata beneath the surface consist of more than one kind, each kind may be leased separately, and to a different person from those who lease the rest. Something of this kind occurs at Hurlet. The property is held by the Earl of Glasgow and others parties, and the surface ground has, as such, no interest in these sources of wealth; other leases are granted, according to the kind of mineral which is to be worked; and thus there may be four or five leases, and as many leases, co-existing at the same time in the same pits.

For instance, the Hurlet Alum Company rent all the alum found throughout a certain extent of country, but have nothing to do with the iron, the coal, or the lime found in the same pits which yield the alum, those ores being leased to other parties. It thus arises that there may be, and are, different sets of miners at work at one time in the same series of labyrinthine passages, some to collect one kind of material and some another; each party independent of the others, in respect to the contract with the employers, the mode and rate of payment; the kind of tools employed in the process, the mode of procedure. This explanation will enable us better to understand what meets the observation when down in the pits.

The alum-ore is drawn up to the surface near the buildings where the subsequent processes are conducted; but the men descend to the mine at the distance of half a mile from that spot, the same shaft serving for the various classes of miners. This shaft is in the middle of a field, and presents to view nothing more than a square opening measuring about six feet each way, guarded by slight wooden palings at the margin, and having ladders of very small size for the descent. The depth is not very great—inconsiderable, indeed, when compared with that of the mines whence metallic ores are procured; and hence the descent has nothing about it very fatiguing. But once turned at the bottom, we are just as much excluded from the light of day and are exposed to the same rough usage as if we were ten times as far beneath the surface. An old coat and cap, a thick pair of boots, a little lamp, and a little courage must prepare us for our groping excursion; and we soon find that not one of these can well be spared.

When we follow our guide from the bottom of the descent into the passages of the mine, the profound darkness has at first a very bewildering effect; for the earthly lining of the passages is so nearly black that it
reflects very little of the light from the small lamps carried in the hand, and thus the lamps seem like so many marks of light seen—fixed stars. Under foot, the soil is rather wet and sloppy, and over head the roof is so low, that a stooping posture is unavoidable. By degrees, the holes are increased to the peculiar gloom of the place; the lamps, which at first only rendered the "darkness visible," now throw a faint glimmer upon a few prominent points, from which we find that we are walking through a low arched passage.

On the occasion when we groped through this mine, we accompanied two of the managers, one of whom had cognizance of and superintendence over the operations for the collection of alum, while the other superintended the coal and lime mines: and we thus had an opportunity of seeing most of the operations going on. After having walked "in single file," for some considerable distance, we came to a spot where a number of glimmering lights showed that mining operations were being carried on. Some men were seated on heaps of coal, nearly shrouded in darkness; while others, with bits of lighted candle stuck in their caps, were digging and shovelling coal. One man was preparing a blast; that is, he was placing gunpowder in a cleft of solid coal rock as a means of giving it. When his operations were completed, all the men retired to a respectful distance, there to remain till the explosion was over; and this interval of a few minutes, though mere matter of course to the miners themselves, is suggestive of some awkward thoughts to those who are new to the subject; for an indefinite expectation of some mischief, which we can neither measure nor guard against, is very apt to arise. However, in the course of a few minutes the fuse was kindled, and the gunpowder exploded; and it was then to be seen that a large mass of coal had been loosened from its bed, upon which the miners immediately set to work.

Having left this spot, we continued our groping through a long series of arched passages; some wet, some dry; some having a railway on the floor for drawing up the "curves" or barrows of coal from a lower level; some high enough to permit walking in an erect posture, others (and these the greater part) so low as to render a painful stooping posture indispensable; some several feet wide, others wide enough only for one person to pass at a time. These passages branched out from one another at all angles and in all directions, till no one but a practised person could form the least conception of the course we were taking, whether away from or round again towards the entrance. For the most part these passages were deserted coal strata; all the coal having, in the course of years, been removed, except certain portions which were left as pillars to support the roof; and as the stratum of coal thus removed declined at a certain angle in one direction, the void passage acquired the same slope, and thus the transit through the mine is an incline, upward or downward according to the direction.

At one part of the mine we came to a spot where a party of lime-miners were at work. The lime was in the form of very hard stone, and the removal of it was a laborious task. The men had had the upper part of the body naked, with the exception of the cap, which held the bit of lighted candle; and some, in the intervals of work, were seated on low heaps of stone or rubbish, smoking their short pipes. As to their conversation, it was very little more to be understood by a stranger than Gaelic would have been; for the miners' language is full of words not in use elsewhere, or else differently applied.

For instance, in the lead-mines of Derbyshire, a 'gooff' is an old working open to the sky; a 'country' is a rock through which the work has traversed; and 'trick' is the rubbish or refuse from a mine; again, in Cornwall, a 'trouble is a break in the continuity of a vein; an 'oldman' is a plaster in former ages; and so forth—many of the terms and phrases being common to all miners, while others are peculiar to certain localities. Another group of miners, warning some oatmeal 'paritch' over a small fire, and enveloped in the smoke, formed a curious patch in the dusky landscape.

While walking along the arched passages, if the hand were passed over the surface of the roof, or if the hand—from a want of proper humility—struck against it, we could easily see that the roof was coated with a crumbling powdery substance, easily scraped from the solid rock. This was a decomposed state of the mineral which was afterwards to yield not only alum, but also copper; the air and damp of the mines having in the course of years brought to an efflorescent state that which would otherwise remain an inorganic substance. In other parts of the vaulted passages specimens of copper occasionally peeped up, in which a hard chalky substance was interstratified with layers of a greyish-white crystalline, on which time the sand, being laid down, a brownish-black kind of coal-slate was the form in which the alum-ore presented itself, always occurring above where the coal had been, not necessarily so. At another place, being the lowest part of the mine, an area of several acres of water had collected, entirely occupying the deserted workings at that part. This water, when tested, was found to be strongly impregnated with the two salts—copperas and alum—resulting from the decomposition of the alum-ore which had dropped into the water, or over which the water had trickled.

After groping in this way for three hours, to a distance of four or five miles through the apparently impenetrable passages of the mine—some of which belonged to one proprietor, some to another, but all leased—in respect to the alum—to one party—we returned to the entrance; not unwilling to exchange a stooping attitude and a dim glimmer for free movement and the light of day.

Let us next see the process to which the alum-ore is subjected. In these mines there was originally a stratum of alum, with a stratum of lime above it, and then, the two a thin stratum (varying from two to twelve inches in thickness) of ore containing most of the chemical elements for alum. So long as the coal was not worked, the alum probably remained undiscovered, or at least unknown; but when the whole stratum of coal was removed, the stratum of alum above it was laid bare. In this stratum there are, among other elements, sulphur, alumina, and iron; and these, by the long-continued action of air and moisture, lead to the formation of sulphate of alumina and sulphate of iron. But heat will also lead to this transformation; and thus the operations of the alum-works involve two varieties, one for the efflorescent ore, and the other for the stony ore.

Supposing the crumbled ore (which has a greyish colour and a salt taste) to be scraped and collected from the pit, it is put into large iron vessels called "steeps," freely exposed to the air. It is there covered with water partially impregnated with sulphate of iron and alumina, and allowed to remain undis-turbed for several hours, during which time the sulphates become dissolved in the water, and the earthy residue subsides. The water, having imbied the saline matter from the ores, is then drawn off to a settling basin, and the half-spent ore is stoned again and again with fresh water, until all the soluble matter is completely exhausted.
In the cistern the earthy sediment wholly separates, and from thence the liquor is pumped into a series of long-arched boilers, so formed as to apply heat to the surface of the liquid. By this means a considerable portion of the water is evaporated, and the highly concentrated liquor is then transferred to large coolers, where it remains about a fortnight undisturbed. During this interval a process of crystallization goes on: the liquor contains sulphate of iron (copperas) and sulphate of alumina, and the former of these separates from the latter by gradually crystallizing. Sticks called 'riders' are immersed in the liquid in the coolers, and around these sticks large bundles of beautiful green crystals collect, forming the well-known but absurdly named 'copperas' of the shops.

When the crystals of copperas have been removed, the remaining liquor is drawn off into an evaporating boiler, in order that the sulphate of alumina may go through the same process as the copperas; and, after boiling to a certain strength, the liquor is drawn off into a cooler. Sulphate of alumina will not crystallize without the addition of potash or some other alkali, and potash is therefore put into the cooler with the liquid, by which, after some days' standing, crystals of alum are produced, those crystals being a sulphate of alumina and potash. After this follows other processes of boiling, evaporating, and crystallizing, for the purpose of purifying the alum—processes which give rise to the distinctions of 'green alum,' 'white alum,' and 'finished alum'; but into these details we need not enter.

When, instead of the efflorescent or powdered ore, the hard or stony ore is used, a preparatory process is necessary. This ore (which in appearance is somewhat mid-way between slate and stone-coal) contains sulphur, iron, and alumina, like the decomposed ore; but these three elements have not yet been combined into the sulphates of iron and of alumina; and the aid of fire is necessary for this transformation. The ore, after being broken into small pieces, is built up into long ridges, with feet beneath and air-holes in different parts; and here it is burned as a preparative process.

It will thus be seen that the copperas is an extra prize which the alum-maker obtains from the ore, when the latter has been decomposed by the air; and that the four main processes, varied somewhat in detail, are roasting, steeping, boiling, and crystallizing; and the alum thus made is thoroughly ready for use in dyeing, in tanning, and numerous other branches of manufacture.