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A mineralogical Outline of the District containing the Aluminous Schistus, in the County of York, with the entire Process practised in the Manufactory of Alum: to which is added an Analysis of the Sulphate of Alumine, and the Supersulphate of Alumine and Potash, with practical Observations and Remarks: communicated by Mr. RICHARD WINTER.

THE stratum of aluminous schistus bordering upon the sea, presents cliffs that are in general precipitous. Their height is from 100 to 750 feet. Strata.

The sea has made, and is continually making considerable incroachments upon the land, particularly to the southward of Whitby. The abbey, built in the year 656, was situate near one mile from the sea; at present the distance is not 200 yards. Sea encroaching on them.

This wasting of the cliffs is principally occasioned by the decomposition of the schistus from exposure to the atmosphere, and the subsequent action of the wind, rain, and breakers of the ocean. In walking under the perpendicular parts of the cliffs considerable danger is to be apprehended from the fragments of stones &c. continually falling down. Several instances have occurred of a very unfortunate nature, Owing to decomposition.

nature, from a want of precaution, and of a knowledge of these circumstances.

The stratum 29 miles wide Direction E. & W.

The stratum of aluminous schistus is about 29 miles in width, extending from 10 miles to the southward of Whitby to 18 miles to the northward. The general direction of the stratum is from east to west, as may be inferred from its being found in the interior of Yorkshire and Lancashire.

The sea coast most eligible for alum works.

Those places immediately upon the coast are, however, the most eligible for the erection of alum works, as they possess advantages, which it is absolutely necessary the manufacturer should embrace. The immense quantity of refuse schistus and rubbish (as the covering strata of the aluminous schistus are called) to be removed, renders it requisite to erect the works in such situations as to be able to get rid of these substances with the most expedition and the least expense. The charges for draught work is materially diminished, as the coals are brought by sea from the ports of Sunderland or Shields, and delivered at the manufactory: but in those works situate in the interior, they lie under a considerable expenditure for carriage, from which the other is exempt; so that we need not be surprised at the gradual reduction of the works in the interior from seven or eight to only one remaining.

Of the Strata reposing upon the Aluminous Schistus.

Covering strata

The strata, which are generally found covering the schistus, are alluvial soil, sandstone, ironstone, shale, and clay.

Minerals of the same species, as are found in the superincumbent strata, may be collected with the greatest facility upon the seashore with additional fossils cast ashore by the waves, after having been brought down by the rivulets, or fallen from the cliffs, and afterward washed by the action of the tide *.

Stones contained in them and found on the shore, with

The variety of agates, and fossil wood converted into agate, are numerous, and equally beautiful with those brought from Germany, and admit of as high a polish.

The cornelian, mocha, onyx, opal, and chalcedony, are

* Any person, who may be desirous of obtaining any of the mineral productions of this neighbourhood, may be supplied on application to me, by letter or otherwise.

found

found in beautiful specimens, and are sought after with avidity; they are chiefly cut into seals, bracelets, rings, and other ornaments. other substances thrown up by the waves.

Garnets are found imbedded in quartz. These occur but rarely.

A variety of flints resembling the Egyptian pebble are very common; these, when broken, present a number of concentric lines, resembling the different yearly growths in timber; and variously coloured. Sometimes fossil echini are found enclosed in the flints, others contain cubical pyrites.

Jaspers of a red and green colour, elegantly variegated, occur in abundance.

Some of the nodules of quartz contain very fine small rock crystals, regularly formed.

Mica is sometimes to be met with in the sandstone strata.

Two species of hematites, or bloodstone, red and green. The green is very scarce.

Pieces of amber are sometimes thrown ashore by the sea.

Coral is also found but of a very inferior kind.

The os sepiæ, or bone of the cuttle fish, is common, the fish itself is often cast ashore.

The madreporæ are frequently to be met with.

Puddingstone, porphyry, granite, and whinstone are found in masses of various sizes.

The metallic ores are less numerous. Iron is the most predominant.

Manganese is met with in small quantity, in the state of a black oxide.

Lead has been found crystallized, but the specimens are rare.

The sandstone strata are found of various qualities, seldom very white, generally of a brownish red: sometimes the quantity of ferruginous matter contained in them is so considerable, as to make them very hard. Even the softer kind of sandstone, by exposure to the atmosphere, is found to grow much harder, so that it is very useful in building. The thickness of the strata varies from four yards to upwards of fifty: the general inclination or dip is to the S. W. Sandstone strata.

Immediately under the sandstone strata are to be found springs Springs.

springs of very good water, some of them highly impregnated with iron, united with carbonic acid gas; the acid becomes disengaged by exposure to the air, and a copious precipitate of the iron, of a dull red colour is deposited. The temperature of several of these springs is from 44° to 46° Fah. uniformly throughout the year.

Coal and jet. Under the sandstone is frequently found a seam of coal, or jet, of an indifferent quality. Sometimes these occur enclosed in the substance of the sandstone, but they rarely exceed two inches in thickness, and are of no great extent.

Clay. The clay is chiefly alluvial, or derived from the decomposition of shale. The colour is generally of a bluish gray, sometimes of a yellow ochrey colour. The thickness of the strata may be averaged at two feet.

Ironstone. The ironstone is found in loose or broken strata, from two to twelve feet thick; the quality is much inferior to those seams of iron ore found in the aluminous schistus, noticed hereafter. Its specific gravity is about 3·1. It may here be remarked, that the whole of the strata are traversed by veins, intersecting each other at right angles, in a southerly and an easterly direction. The masses, both of the schistus and sandstone, always appear in the form of solid parallelograms, occasioned by the crossing of the veins, the longest side of the solid lying between N. and S. I have noticed, that, when the stratum of clay has been uncovered for a considerable time in the summer season, on the abstraction of water from the clay it cracked in regular divisions, of the same rectangular figure as those visible in the sandstone and schistus. This observation on the regularity of the divisions assumed by alumine in drying is noticed by Chaptal (Chemistry applied to the Arts, vol II, p. 46). Perhaps the formation of the basaltic pillars may have been effected by this combination of fire and water in some gradual manner.

Of the Mineral and Fossil Bodies found in the Aluminous Schistus.

Fossils found in the schistus. A very pure native alumine is found enclosed in a nodule of stone resembling indurated clay. Several species of ammonitæ are found enclosed in an argillaceous ironstone of of a double convex form. Two or three species of nautili occur, these last are rarely found in a perfect state. The belemnitæ are very abundant. The trochitæ are found, but no i great abundance. The fossil vertebræ and other bones of animals are frequently found, the form of which has been but little deranged. I found a part of the os femoris of an animal with the trochanter and the foramina very evident; the part where it was broken measured 4·2 inches in diameter, so that its length when in a perfect state may be inferred to have been at least 4 feet. The shells are numerous, of various species, and some of these are in a state of great preservation.

Naphtha is sometimes found enclosed in an ironstone of a globular form. Jet is found in abundance, frequently the bituminization is not perfect, and one part of the substance presents us with pure jet, while the other is still in the state of petrified wood: in this state it is most commonly found, in breaking up large masses of iron ore.

There is an immense quantity of red iron ore, found in strata, at the depth of about 200 feet from the top of the aluminous strata: the thickness of these seams of ore vary from about a few inches, to about 2 feet. In some situations four or five of these strata are found alternating with schistus. The specific gravity of this ore is from 3·4 to 4·2. It contains, upon analysis, from 30 to 60 per cent of iron, combined with oxigen, phosphoric acid, lime, alumine, and silex. Considerable quantities of this ore are collected, and carried down to Newcastle, and smelted at the founderies erected there for this purpose.

Sulphate of lime is found crystallized in radiated and striated crystals; but this is at considerable depths in the rocks.

Carbonate of lime is generally found crystallized, filling the veins which intersect the aluminous schistus. The thickness of these veins of crystallized carbonate of lime is generally 0·5 of an inch, and they are of considerable depth.

An ingenious landscape painter, and a good mineralogist, Mr. Bird, of this place, has recently discovered a new variety of alum rock, containing silex and sulphur, with oxide of iron. This rock effloresces on exposure to the atmosphere, and

New variety of alum rock.

and a sulphate of alumine is produced., The stratum is of great extent, and inestimable value. I am not permitted to point out its situation.

Aluminous schistus.

The aluminous schistus is generally found disposed in horizontal laminæ. Sometimes it exists in the form and appearance of indurated clay; in fact the whole of the upper part of the stratum resembles indurated clay, when first wrought; but by exposure to the atmosphere it suffers decomposition, and crumbles into thin layers. The upper part of the rock is the most abundant in sulphur, and the deeper they work into it, the quantity of sulphur decreases, and the bituminous substance increases, and the rock becomes more hard and slaty; so that a cubic yard of rock, taken from the top of the stratum, is as valuable as 5 cubic yards taken at the depth of 100 feet.

When a quantity of the schistus is laid in a heap, moistened with sea water, it will take fire spontaneously, and will continue to burn until the whole of the combustible materials are exhausted.

A considerable part of the cliff some years ago fell down in a situation where it was exposed to the sea at high water; in a short time afterward combustion had taken place throughout the whole extent of this small volcano, and it continued to burn for two or three years before it became extinct. Does not this fact explain the nature and cause of volcanoes? This point I am aware has been ably illustrated in the spontaneous inflammation of pyrites, the artificial volcano of Lemery, and more particularly by the indefatigable Spallanzani, and Sir W. Hamilton.

Volcanoes.

The whole extent of the aluminous strata bears evident marks of a volcanic nature. It is intersected by whin dykes, and wherever the coal strata come in contact with these dykes, the coal is charred to some distance. Wood is also found in every part of the schistus converted into charcoal. Jet appears to be some vegetable substance, that has been acted upon by considerable pressure, and some degree of heat, not sufficient to convert it into charcoal; it frequently has the appearance of a cylinder having undergone an immense pressure, and the centre filled with pyrites. The accumulation of sulphur towards the top of the strata, as if it had been sublimed—these facts seem to countenance the

the idea, that this is a volcanic country, where the degree of heat has not been sufficient to put the rocks into a more rapid state of combustion; or for want of the access of the sea into the interior parts of the Earth. Who can determine, that nature has not yet remaining rocks, which may become volcanoes in some future ages, when the sea has found a sufficient inlet into the bowels of the Earth.

The observations I have made with regard to the chemical nature of the schistus are merely indicative of the substances contained in it. Indeed experiments would only exhibit a conjectural, and not a real analysis of the schistus, unless a considerable number of them were made at different depths, and in various situations of the stratum.

The colour of the aluminous schistus is a bluish gray. Its hardness differs; at the top part of the strata it may be crumbled in pieces between the fingers, at a considerable depth it becomes as hard as roof slate. The specific gravity is about 2·48. Characters of the aluminous schistus.

Alcohol digested upon it, and afterward evaporated, leaves a residuum having all the properties of petroleum.

Olive oil, digested upon the schistus, acquired a dark brown colour, most probably from bitumen.

Exposed to a red heat for a considerable time it loses 15 per cent, and assumes a whitish colour, if taken from the top of the rock, and a dull red colour, if taken at about the depth of 40 yards.

Dilute sulphuric acid was poured upon a portion of the schistus; and upon adding prussiate of potash, an abundant, precipitate of prussiate of iron was thrown down from this solution.

Ammonia precipitates a very considerable proportion of alumine, amounting to 30 per cent, in some instances.

Oxalic acid discovers the presence of lime and magnesia.

Fused with an alkali, muriatic acid precipitates a large proportion of silex.

Hence the aluminous schistus contains silex, alumine, magnesia, lime, oxide of iron, bitumen, sulphur, and water.

Of the Calcination and Lixiviation of the Schistus.

The covering strata are removed previous to working the Method of working it.

Method of working the schistus.

the alum rock (as it is generally called). The hewing of the rock is performed with picks and javelins; and it is conveyed to the calcining place in barrows, so contrived, that the centre of gravity of the weight, is in a perpendicular line passing through the centre of the axle of the wheel; by this means the men have nothing more to do, than to keep the barrow steady, throw the weight of the substance upon the wheel, by raising the handles, and direct the barrow upon the way, which is formed of cast iron plates, 6 feet in length, 6 inches in breadth, and half an inch thick; these plates are fastened into cross pieces of wood fixed into the ground, at the end of each plate. Ten of these barrows contain one solid yard of the rock. The expenses of working the rock vary according to the facility with which it can be hewn. When the distance the rock is to be barrowed is about 200 yards, the rate for removing and hewing one cubic yard is about 6½d. It is unnecessary to state, that the price must maintain a corresponding ratio with the distance to be conveyed. The men earn about 2s. 6d. per day in the winter season, and 3s. in the summer.

The rock is poured out of the barrows upon a bed of fuel, composed of underwood, furze, &c. The dimensions of this pile of faggots is about four or five yards in breadth, and two in height; as the rock is deposited upon the fuel, it is necessary that it should be broken into small fragments, that the combustion may take place with the greater facility. When they have got about four feet in height of the rock upon the faggots, fire is set to the bottom, and fresh rock continually poured upon the pile; other piles of wood are then placed alongside of the first, and they proceed as before, adding more rock, firing the fuel, &c. This they continue, until the calcined heap is raised to the height of 90 or 100 feet, and from 150 to 200 feet in length and breadth. Some of these heaps of calcined mine (as it is now called) will contain 100,000 solid yards of schistus or rock.

When the whole heap is in a state of combustion, a considerable quantity of sulphureous acid gas is disengaged, this they endeavour to prevent, by moistening small schistus, and forming a kind of clay; with this they plaster the outside

side of the heap, this however does not prevent the escape of the gas in any degree, but it prevents the wind from penetrating, and assists in preventing the calcined mine from falling, by forming a kind of crust all over the heap; this crust is soon decomposed by the action of rain, &c.

The form of the places for calcining the rock in is badly calculated to prevent the escape of the sulphureous acid gas. If the combustion was effected in a building of the shape of a smelting furnace, immediately upon the whole of the rock becoming ignited the openings might be closed, and the gas preserved. I have ascertained by experiment, that nearly one half of the sulphureous acid gas is expelled by a red heat, continued for a considerable space of time.

Difficulty of introducing improvements.

Every suggested improvement is considered as an innovation by the illiterate, and it may be truly said, to be more easy to remove mountains than long established prejudices; the anxious manufacturer is seldom sufficiently master of his works, so as to be able to turn the scale of long established custom: and the most enlightened and scientific methods are entirely defeated, when trusted to the hands of workmen to carry them into execution.

How little melioration can be expected among a class of people, where reason has never made any impression upon the mind! I would hail the man as a true patriot, who shall endeavour to disperse this cloud of darkness from the human race.

The sulphureous acid gas, by absorbing oxigen from the atmosphere, is converted into sulphuric acid; this change is effected by means of the oxide of iron contained in the mine, and moisture. It would certainly be worth ascertaining by experiment, whether the oxide of iron combined with sulphur in burning would not yield sulphuric acid if moistened with water.

I am aware that iron has a greater affinity for oxigen than sulphur has in the fire, but in the great scale of nature she observes laws peculiar to herself: the affinities observed in the salts of the ocean are contrary to the order they appear in our tables, here, we find the small portion of sulphuric acid united to the lime; instead of forming a union with the soda, as might be inferred. Lime is found to decom-

pose

pose the muriate of soda. These, and other anomalies might be produced, but they are foreign to the purpose.

Making the alum.

130 tons of calcined mine will produce 1 ton of alum. I have deduced this number from an average of 150000 tons of calcined mine consumed.

The calcined mine is steeped in water, contained in pits, that usually hold about 60 cubic yards. The water thus impregnated with sulphate of alumine, called alum liquor, is drawn off into cisterns, and afterward pumped up again upon fresh calcined mine. This is repeated until the liquor becomes concentrated to the specific gravity of 1·15; or 12 pennyweights of the alum maker's weight. The half exhausted mine is then covered with water, successively, to take up the whole of the sulphate of alumine; these liquors, thus impregnated, are denominated strong liquor, seconds, and thirds.

The strong liquor is drawn off into cisterns, to deposit the sulphate of lime, iron, and earth suspended in it. In order to free the liquor from these substances, they clarify it by boiling for a short time, which enables the sulphuric acid to exert its affinities with greater energy. After running it from the pans, and suffering it to cool, the whole of the sulphate of lime, iron, superfluous alumine, and earth, are deposited; and the alum liquor is nearly pure. Where this precaution is used, the alum is much better in quality, and almost entirely divested of the sulphate of iron. This method is only practised at some of the works, owing to the additional quantity of fuel required, and consequently increased expense.

The liquor in this state is carried by means of pipes, or wooden gutters, into leaden pans. These pans are made of sheet lead (cast by the workmen in the alum house) 10 feet long, 4 feet 9 inches wide, 2 feet 2 inches deep at the hinder part, and 2 feet 8 inches at the front end: this difference is allowed to give a rapid current in running off.

A quantity of mothers is pumped into the pans every morning; and, as this evaporates, the deficiency is supplied with fresh alum liquor, every two hours, or, as the liquor in the pans becomes more concentrated, the additions are made more frequently. It is necessary to keep the pans continually

continually boiling, otherwise the superfluous alumine and sulphate of alumine, deprived of its water of crystallization, would be precipitated, and the pans melted, from the crust formed between the liquid and the lead.

Each pan will produce upon an average 4 cwt. of alum daily, and the consumption of coals will be about 18 bushels Winchester measure.

The liquid contained in the whole of the pans is run off every morning into a vessel called a settler, at the same time a quantity of alkaline lee is brought along with the boiling liquor, prepared either from kelp, soapers lees, (generally called black ashes) or muriate of potash, of a specific gravity from 1·037, to 1·075. The alum maker having previously ascertained the specific gravity of the liquid in his pans, estimates the quantity of alkaline lees to be added, necessary to reduce the liquor from the pans from the specific gravity of sometimes 1·45 or 1·5 to 1·35.

The liquor then stands in the settler about two hours, that it may deposit the sediment it may contain, when it is run off into the vessels (or coolers) to crystallize.

If the alum maker should be below, or equal to the specific gravity of 1·35, in mixing the alkaline lee and liquor, there is nothing more to be done. If he exceed this specific gravity, he then adds urine in the coolers, until the liquid is reduced to 1·35. It is then agitated to combine the heavy and light liquids, and then left to crystallize. It must be observed, that at a greater specific gravity than about 1·35, the liquor, instead of crystallizing, would present us with a solid magma resembling grease.

After standing four days, the mothers are drained off, to be pumped into the pans again the succeeding day. The crystals of alum are conveyed into a tub, where they are washed in water, and put into a bin, with holes in the bottom, to allow of the water draining off from the alum. They are then removed into a pan (twice as large as the common leaden pans), and as much water added as is found requisite to dissolve the whole of the alum when in a boiling state: the moment this is effected, the saturated boiling solution is run off into casks. These casks should stand about 16 days; as they require this time to become perfectly

fectly cool, in the summer season. The casks are then taken to pieces, and a hollow cask of alum is produced; it is then broke into, and the whole of the saturated solution of alum (called tun water) is removed back into the pans, to go through the process anew.

This last process is called roching. The outside of the cask of alum is now to be cleared from dirt, and the sediment which is deposited at the bottom. It is then broken up into masses ready for the market.

Practical observations and remarks upon the foregoing processes.

Method of ascertaining the specific gravity.

The method pursued by the alum makers to find the specific gravity of any liquid is capable of considerable accuracy. A bottle is procured, that will contain about ¼ of a pint. The narrower the neck, the more accurate will be the results obtained by it. This bottle is balanced in a pair of sensible scales, we will suppose it to weigh 1000 grains, it is then filled with distilled water, and carefully dried with a cloth; now allowing the water to weigh 2400 grains, this last number is divided into 80 parts or pennyweights, and we have 30 grains corresponding to one pennyweight; this they subdivide into ½ and ¼. Hence we may ascertain the relative specific gravity of any liquid. 1 pennyweight is equivalent to 1·0125, and 80 pennyweights to 2·0. Care however is necessary, to have a counterweight of 3400 grains, equal in weight to the water and bottle together, which must always be put into the scale, along with the other weights, in operating. This was formerly a great secret among the alum makers, and they sold the method at a high price, or handed it down to their children as an hereditary possession.

Improvements suggested.

Considerable advantage might be derived to the manufacturer, by reducing the size of the fire places, and erecting iron doors, to prevent a current of air passing over the fire, instead of entering by the ash pit: a very material saving of fuel would arise from adopting this method.

A very material errour is committed, by concentrating the liquor in the pans to near the specific gravity of 1·5, and

and then reducing it again to 1·35: this method obliges them to evaporate a very unnecessary quantity of water.

The alum liquor is frequently brought into the pans as low as 1·09; when by repeatedly bringing the liquor over fresh calcined mine, it might be concentrated to 1·25, or more. I will mention an instance where the expenditure in evaporating liquor was more than £3 10*s.* daily; when at the same time this liquor might have been concentrated to an equal degree, by repeatedly pumping the liquor upon fresh calcined mine, at an expense of not more than 9*s.* in the same time; here there was a loss of £3 1*s.* daily.

In using black ashes, or kelp, a considerable quantity of charcoal is dissolved in the alkaline lee; this charcoal is precipitated on adding a small quantity of the solution of sulphate of alumine, but is redissolved again by adding the solution in excess.

This charcoal then contaminates the alum, and decomposes a quantity of the sulphuric acid: therefore, it must appear conclusive, that whatever alum is made with muriate of potash alone will be far superior in quality, while the produce will be greater in quantity.

It might be supposed, that urine was a necessary ingredient in the making of alum; but the fact is, it merely hides the ignorance of an alum maker. Having no determinate rule to guide him, in reducing the liquor from the pans, should he chance to exceed the specific gravity of 1·35, he adds urine, or some such light fluid, to bring the liquor as near as possible to this density. The alum works, that approach the nearest to the true chemical principles, are those of the Right Hon. Lord Dundas, and Messrs. Baker and Co. They use no urine in these works—the alum liquor is always clarified previous to its being used—they use no alkali generally, but crystallized muriate of potash—greater economy is observed in the consumption of fuel; and the result is a product of alum considerably larger in a given time, and of better quality, than can be produced by the works established upon the old plan.

Remarks on the alkalis employed in the manufacture.

The kelp used is obtained by burning the sea wrack in kilns, at a great number of places upon the coast of England, Scotland, &c. It is a very inferior alkali in an alum manufactory.

manufactory. It contains about 47 of soluble salts, and 53 of charcoal, sand, and earth. The salts are muriate of soda, soda, and sulphate of soda.

The refuse of the soap boilers' lees are burnt in a kind of oven, and sold under the name of black ashes. The composition of these ashes is about 90 of soluble salts, and 10 of charcoal and earth, the salts contain muriates of soda and potash, sulphate of potash, and muriates of lime and magnesia.

I have always found great difficulty in producing alum by the muriate of soda, and never could form alum in any way by means of pure soda.

The muriate and sulphate of potash are the only alkalis that can be used to advantage in the composition of alum.

I have made comparative experiments to ascertain the quantity of the different alkalis it would require to produce 100 tuns of alum. The following are the results:

22 tuns of muriate of potash will produce 100 tuns of alum,
31 ditto of black ashes .... 100 ditto,
73 ditto of kelp .... 100 ditto.

The alkalis are considered as in the state, in which they are found in commerce.

Analysis of sulphate of alumine, and supersulphate of alumine and potash.

Analysis of sulphate of alumine.

I have been generally disappointed in analyzing alum on finding my results at variance with those of so many eminent chemists. It appears, that the errour has existed in their different estimations of the composition of sulphate of barytes. It seems, that allowing about 33 per cent of acid is very near the truth*. By taking it in this ratio, the acid

* According to some very careful experiments made by Mr. Arthur Aikin, see Journal, vol XXII, p. 301, it is nearer 34. He makes it 33·96; and according to Klaproth it is 33·55. - See also an Analysis by Mr. James Thomson, vol. XXIII, 174; and another by Berthier, ib. p. 280: both of whom make it at least 33. C.

used,

used, and the quantity of alum produced upon a large scale nearly correspond.

I know of no experiments, that have been made to ascertain the composition of sulphate of alumine, except Bergman's. I believe Vauquelin has done the same, but as I have not seen his paper, I cannot speak to that effect. Bergman states the composition

Sulphuric acid	50
Alumine	50
	100

From a solution of pure sulphate of alumine in water I precipitated the acid, by means of the muriate of barytes added in excess. The precipitate, after having been carefully washed upon a filter, was exposed to a white heat for some time. The quantity of acid inferred from the sulphate of barytes obtained, was 287 grains.

To an equal quantity of a solution of sulphate of alumine, ammonia was added to saturation; the precipitate, after washing upon a filter, was exposed to a white heat for an hour, and weighed 209 grains. Therefore sulphate of alumine is composed of

Sulphuric acid	57·8
Alumine	42·2
	100·0

Analysis of alum.

Analysis of supersulphate of alumine and potash.

Exp. 1. To 10000 grains of a very pure crystal of alum, dissolved in rain water, was added muriate of barytes, until no farther precipitate took place. The sulphate of barytes, after having been well washed upon a filter, was exposed to a white heat for some time, it weighed 3359 grains.

Exp. 2. To 10000 grains (of a part of the same crystal, as used in the preceding experiment) in solution, was added ammonia, until the precipitation was found to be complete. After washing and filtering the alumine, it was exposed to the heat of a blast furnace, and found to weigh 1096 grains.

Exp.

Exp. 3. The remaining solution of the 2d experiment, after boiling quicklime in it to take the acid from the ammonia, was evaporated to dryness, and afterward exposed to a red heat. The potash, or soda, thus produced, weighed 858 grains.

I repeated the analysis twice, the results, after taking every precaution, are as under:

	1st Exp.	2d Exp.	Mean of the two.
Sulphuric acid	33·59	33·10	33·34
Alumine	10·96	11·81	11·38
Soda or potash	8·58	9·74	9·16
Water	46·87	45·35	46·12
	100	100	100.

In finding the quantity of water contained in crystallized alum, by exposure to a red heat, an uncertain product will always be given, arising from the degree of heat employed in the desiccation of the alum. At a white heat a very considerable proportion of acid will be expelled, as well as the water.

In the production of alkali from the alum, I have called it soda, or potash. I did not institute any experiments to ascertain the quality of the alkali, but as nothing but kelp and black ashes had been used in the fabrication of the alum, it is evident the alkali must have been soda with perhaps a small proportion of potash. So that in reality we have a fifth variety in addition to the four described by Dr. Thomson.

It remains then of some importance to the consumer to ascertain the difference between alum made with potash, and that in which a salt of soda is used.

I have received considerable advantage from the very able memoir of Messrs. Thenard and Roard, as inserted in your Journal, vol. 18, page 276.

Had these philosophers adopted 33 per cent of acid in the sulphate of barytes, instead of 26, as is stated in their paper, our results would not have been very different. By correcting their statement of the composition of alum, according

cording to the estimate of sulphate of barytes, which I have used, we shall find it to be

Sulphuric acid	33·05
Alumine	12·53
Potash	7·90
Water	46·52
	100.

Whitby, 10th March, 1810.

II.

Tools to answer the Purpose of Files and other Instruments, for various Uses, made of Stone-ware. By G. CUMBERLAND, *Esq*.

To Mr. NICHOLSON.

SIR,

TO some men, but not to you, will it appear a trifle, because very obvious on reflection, to have applied so soft a substance as clay to the purpose of lograting the hardest bodies; neither should I perhaps have ever thought of such an application in the form I now use it, had I not found, in shaping some substances, that the wear of my steel files was rather expensive. Clay employed to abrade hard bodies.

It then first occurred to me, in ranging in thought after a remedy, that, as our stone-ware is so hard as to blunt our files, files might be as well made of our stone ware. This was about two years ago, and the first use I made of the suggestion was, to fold up in muslin, cambrick, and Irish linen, separate pieces of wet clay, forcing them by the pressure of the hand into the interstices of the threads, so as on divesting them of the covering to receive a correct mould. These I had well baked, and immediately found I had procured an intire new species of file, capable even of destroying steel; and very useful indeed in cutting glass, polishing, and rasping wood, ivory, and all sorts of metals. Tools made of it for this purpose.

The ease with which I had accomplished my purpose, as is too often the case, made me content myself with the use of Uses to which they may be applied.