*The **workmen** are divided into two parties, with an **overseer**, or* <u>*tally-man*</u>*, to see that the assigned number of journeys is duly performed; and as they all run the same distance, whilst one party is out upon the journey, the other is employed each in filling his own barrow, which prevents all interruption and confusion. By thus proportioning the size of the barrows to the strength of the workmen, boys of twelve or fourteen years of age find employment; and when a man, through age or infirmities, finds himself unequal to a barrow of the largest size, he has an opportunity of making choice of a smaller* [barrow], *his earnings being always in proportion"* (Graves, 1808, 336).

"As the process of making allum has been fully described in Keir's Essay on Chemistry, in Ray's Collection of English words (p.201), in the Philosophical Transactions (No. 842) and other publications, we shall not detain the reader with extracts from these authors, but briefly observe, that the preparation consists in rendering the ore, in the first place [to] *aluminous, and afterwards in dissolving and purifying the salt.*

As most of the allum stone, (which, when dug from the [solid] *rock is of the colour of slate,) is found to contain a mixture of clay and sulphur, the latter must be converted to **vitriolic acid**, before it can form the aluminous combination; which is most expeditiously effected by actual **combustion.***

After the stone, which is thrown into large heaps, has been sufficiently burned, it is put into pits and steeped in water, in order to extract the saline matter, where it remains until the ore is reduced to such a state, as that it may be made into paste with the hand.

The liquor is then run into other pits, where the vitriolic salts are precipitated by the solution of <u>*sal sodae,*</u> *prepared from **kelp**, or the volatile alkali of **stale urine**; and afterwards conveyed in wooden troughs to the allum house, where the superfluous water is evaporated by boiling, which is usually performed in large **leaden cauldrons**"* (Graves, 1808, 336).

"*The* <u>***lixivium,***</u> *when sufficiently concentrated by evaporation, is conveyed through channels into **coolers**, where it is freed by deposition, from the grosser heterogenous particles. In eight or ten days, the lixivium, commonly called magistral water, flows off into another vesses, leaving behind a number of small and impure crystals, which incrust the bottom and sides of the* [cooler] *vessel. These crystals, when collected and washed with cold water, are put into the **boiler** used for purifying them, and dissolved in a small quantity of water so as barely to suspend the salt when boiling hot".* (Graves , 1808, 336).This description seems to have been copied from the 1784 account of Garphyttan alum works in Sweden, published by Professor Torbern Bergman of Upsalla University (Bergman, 1784, 1, 367).

"*The allum liquor* [apparently made from the small cyrstals] *is then poured into large strong wooden casks, in which the allum gradually shoots into large crystals about the sides; the liquor in the middle is then let out by a* [stop-] *cock at the bottom* [of the cask], *and the vessel turned upside down to drain off more effectually the remaining fluid.*

The crystals are afterwards dried in a stove, and finally packed up in casks for sale" (Graves, `1808, 337).

"Mr. *Gough, in his additions to Camden's Britannia, observes that…*[at present] *not more than 3000 tons [of alum] are made annually, which cost the proprietors about 14 L. per ton* [to make] , *and cannot be sold, with a living profit, for less than 16 L. or 17 L. per ton"*.. Under Charles I , Sir Paul Pindar sold alum at £26 per ton, a price which "*appears almost incredible, particularly if we consider that wages, and every necessity of life are now increased four-fold, and yet alum is sold at present at 20 L. per ton; but…[*under Charles I] *they were clogged with a heavy rent…Besides this, the present process of making alum is so much improved in every respect*" (Graves, 1808, 338). The antiquary Richard Gough (1735-1809) produced his augmented version of Camden's 'Britannia' in 1786-99.

"*It is a known fact that* [Yorkshire] *allum has been exported to the Venetian States; and France, before the Revolution* [1793], *was principally supplied with tthat article from this country*" (Graves, 1808, 3380

"*On entering the vast excavation, formed in the centre of the rock, by the hands of man, the spectator is struck with pleasing astonishment, to behold the different strata of earth and rock, arranged with such symmety and exactness, as can no where be found, but in the perfect works of the omnipotent*

[Footnote: *In digging the allum rock, veins of metals* [probably pyrite] *, and soils of diverse colours are found, particalarly those of ochre and murray, from which* ***copperas*** *was formerly extracted; but upon the discovery of pyrites in the coal works in the counties of Durham and Northumberland, that manufacture is carried thither, and discontinued here"*] (Graves, 1808, 338)

Graves also described the nearby **Lofthouse alum works.** Lord Dundas's "*ancestor purchased* [this] *of the late Zachary Moore., Esq. of squandering memory; and whose fathe* …[was] *the founder of the Lofthouse allum-works"* (Graves, 1808, 343).

"*About two miles from the village of Lofthouse towards the north, we visited the allum-works here, the property of* ***Lord Dundas****; which are carried on in the front of a steep perpendicular cliff, washed by the sea; and separated from the Boulby works by a narrow ridge of rock, left as a boundary line by the workmen of the respective proprietors.*

It would be uninteresting to the reader to enter into a description of the works, or to repeat the mode of preparing and crystallizing the allum, being greatly similar to that already noticed in our account of Boulby. We may however remark, that on our approach to the works, we were highly gratified, not only with a view of the vast excavations, which strike the spectator with a pleasing astonshment, but also with the prospect from the summit of the cliffs, which, with the ocean beneath, forms a spectacle truly interesting and sublime" (Graves, 1808, 346)

George Young in 1817 took a more pragmatic viewpoint.:

"PROCESS OF ALUM MAKING The alum of commerce is a triple salt, composed of sulphuric acid, alumine, potash, and water. The method of preparing it from the aluminous schistus had undergone various alterations, having been much improved within the last 30 years. The following is a brief sketch of the usual process.

The top of the alum-rock being laid bare, by removing the alluvial soil and covering strata, the rock is ***hewed with picks****, &c.; the hewing or cutting being continued downwards in different floors, or desses, as they are called, till the rock becomes too unproductive to be wrought any deeper.*

The schistus, when hewn out and broken, is conveyed in barrows to the calcining place, where it is thrown on a bed of underwood, furze [gorse]*, &c.: and when the rock has been heaped over this fuel, to the height of about 4 feet, the pile is set on fire; after which fresh rock is gradually added, so as neither to extinguish the fire, nor produce imperfect calcination. New piles of the same kind are successively annexed to the first, until the calcined heap rises to the height of 90 or 100 feet, and extends from 150 to 200 feet in length and breath.*

Some of these heaps of ***calcined mine*** *will contain 100,000 solid* [cubic] *yards : they are often 8 or 9 months in forming. They are* ***coated with small schistus moistened****, to prevent the escape of the sulphureous acid gas: the latter, by absorbing oxygen from the atmosphere, is converted into* ***sulphuric acid****, which is essential to the formation of alum. – The barrows used in the above operations project over the wheel, so that the centre of gravity falls on the axle; a contrivance which greatly diminishes the tol of the workmen.*

The next stage of the process is to extract the ***alum liquor****, or* ***sulphat of alumine.*** *This is done by steeping successive portions of the calcined mine in square or oblong pits, capable of holding about 60 cubic yards each. The impregnated water* [solution] *is drawn off into cisterns, to be pumped up again upon fresh calcined mine; an operation that ir repeated till the liquor is concentrated to the specific gravity of 1.15, or 12 penny wts. Of the alum-maker's weight, at which strength it is conveyed into* ***cisterns****, to deposit the lime, iron, and earth, which would prevent the crystallization.*

That there may be no waste, the calcined mine in the pits undergoes repeated macerations, till the saline matter is all extracted. ***Liquors*** *of different strengths, called strong liquor, seconds, and thirds, are thus obtained; and the weaker are raised to the proper strength by being pumped on fresh mine* ['schistus' ore]. *These operations have been called working the liquor-turn.- At some of the works, the deposition of the superfluous matter is accelerated by boiling the liquor for a short time, previous to its being conveyed into the cisterns* in which the extraneous substances are deposited. The cisterns are placed behind the alum-house.

When the liquor has been thus extracted and more or less clarified, it is conveyed into the alum-house, into ***leaden pans****, 10 ft. long, 4 ft. 9 in. wide, 2 ft. 2 in. deep at the back part, and 2 ft. 8 in. at the front; the* *bottom being a gentle slope to facilitate the running off. Here the liquor is mixed with the* ***mothers****, the old liquor that has been left* [over] *from former crystallizations, and the whole is boiled 24 hours, fresh liquor being conveyed into the pans from time to time, in proportion as the evaporation goes on;* [so] *that the strength of the boiling fluid may thus be concentrated. The pans are kept continually boiling, to prevent the alumine, &c. from being precipitated; a circumstance which would cause the pans presently* [soon] *to melt.*

The whole contents of the pan are run off every morning into a vessel called a ***settler****;* [and] *at the same time, there is mixed with the liquor a quantity of* ***alkaline lee*** *prepared from muriate* [chloride] *of potash, of a specific gravity from 1.0375 to 1.075.. The alum-maker, having previously tried the strength of the liquor in the pans, which is sometimes so high as 1.45 or 1.5, so proportions the quantity of* [alkaline] *lees* [added] *as to reduce the whole mixture to the specific gravity of 1.35; for if it exceed that strength, the liquor, instead of crystallizing, would only present a thick magma* [gunge], *or unctious mass.*

Having remained in the settler about two hours, to deposit the sediment, the liquor is conveyed into ***coolers****; where it is stirred about for some time, or roused, as the term is, and then left to crystallize. After standing four days, the remaining liquor, which is called the* ***mothers****, is drawn off, or scooped out, to be pumped into the* [evaporating] *pans again the succeeding day.*

The ***crystals of alum****, which chiefly adhere to the sides of the coolers, are carefully collected and put into a* ***tub,*** *where they are washed with water; after which they are conveyed into a* ***bin****, with holes in the bottom, to allow the water to pass through; which water, like the mothers, is reserved for further use.*

They [the crystals] *are then put into a pan, twice as large as the common leaden pans; and, a quantity of water being added, just sufficient to hold the alum in solution, the crystals are dissolved by boiling, and the saturated liquid is poured into casks where the alum crystallizes.*

After standing about 16 days, the casks are taken down, the residuary liquor, called ***tun-water****, is preserved, to be used as fresh liquor; and the* [crystallized] *alum remains as a hollow cask* [shape]. *The outside* [of this alum] *is scraped clean,* [with] *the scrapings, like the water, being kept to undergo a second purification*; *after which the* [remaining] *alum is broken into masses, ready for the market.- The purification, or second crystallization, of the alum, is called* ***roaching****; a term that seems to be derived from Rocca, the name of a place in Syria, the site of the most ancient alum-work in the world* [later renamed Edeffa].

It is only within these [past] *few years, that the process now* [to be] *described has become general. Previous to the year 1789, the alkaline lee was universally prepared from kelp; but at that time* ***black ashes****, made from the refuse of soap-boilers' lees, were introduced along with kelp, and in 1794 the kelp began to be entirely laid aside.*

In 1801, ***muriate* [chloride] *of potash*** *was first used with the black ashes, and in two or three years began to supersede them. Until 1794,* ***urine*** *was considered as a necessary ingredient, and was put in along with the alkaline lee, to reduce the specific gravity of the hot liquor to the proper pitch. Since that time it has gradually fallen into disuse. In introducing these improvements, which are found to be highly advantageous,* ***Lord Dundas****, the proprietor of Lofthouse alum-works, has had an important share.*

New experiments in the art [of alum production] *are generally tried with caution: for, instances have occurred, in which rash attempts at improvements have occasioned the most serious loss. In 1753, an attempt was made at Loftus works to make sea water supply the place of kelp; but it cost the adventurers above £2000. At the same works, a severe loss was sustained in 1746 and 1747, by using Castleton coals for the boiling pans.*

In 1764, the experiment of burning the alum in kilns was adopted at Pleasington in Lancashire; and the undertaking caused a loss above £1000. For some years before 1770, there was no alum-house at Saltwick works; the liquor was conveyed to Shields in vessels constructed for that purpose, to be boiled in an alum-house there; with a view to save expences in the price of coals, kelp, &c. but the scheme was not found to answer " (Young, 1817, 2, 811-814).

"The quantity of calcined mine ['schistus'] required to produce a ton of alum varies, according to the quality of the rock, as well as the management of the process: the mine taken from the upper part of the rock being vastly richer than what is taken from the lower part.

According to an experiment made with great care by Mr. Bathgate, 50 tons of good burnt lime will yield one ton of roached alum, with skilful management: but, in a general way, it requires from 120 to 130 tons of calcined mine to produce a ton of alum.- Each pan is reckoned to produce on average 4 cwt. of alum daily, and to require about 18 bushels of coals, Winchester measure. - About 22 tons of muriate [chloride] *of potash are necessary to produce 100 tons of alum"* (Young, 18`17, 2, 814).

"The present state of the manufacture may be seen from the following table, exhibiting the annual produce of the works now carried on, estimated on an average of the last 12 years.

Works	*Proprietors*	*Average Annual Produce*
Peak and Stoupe Brow	*Messrs Cooke*	*300 tons*
Eskdaleside	*H. W. Yeoman,Esq.*	*270*
Sandsend	*Rt. Hon. Earl Musgrave*	*455*
Kettleness	*Ditto*	*455*
Boulby	*Messrs. Baker and Jackson*	*450*
Lofthouse	*Rt. Hon. Lord Dundas*	*910*
	Total annual average ………	*2840*

In the last two or three years, the quantity has greatly exceeded this average, at least the quantity shipped; for the alum shipped in 1815 amounted to 3077 tons, and in 1816, 3155 tons. Little is exported to foreign ports, nearly the whole being sent to London; yet in former times the exportation was considerable, amounting in 1790 to 1232 tons.

The number of ***workmen*** *employed varies according to circumstances; but the whole number now belonging to the works, including boys and artificers, may be estimated at about 600. Their wages seldom exceed 3s. per day; but they enjoy, in addition, several valuable privilages; among which, a little garden assigned to each family, deserves* to be mentioned. Earl Mulgrave has distinguished himself in making provision for the comfort of his workmen" (Young, 1817, 2, 817).

"The materials for the above account of the alum-works have been chiefly taken from Mr. Winter's Essay in Nicholson's Journal for April, 1810; from communications furnished by John Ridley, Esq., Mr. Bathgate, Mr. Dodds, and the gentlemen of the Custom House; and from the papers of the late Ephraim Jowsey, a noted alum-maker" (Young, 1817, 2, 817).

In the quarries of the 1820s, *"the upper part of the rock, containing most sulphur, is the most valuable for producing alum, a cubic yard at the top producing as much as five cubic yards at the depth of 100 feet. The quarrying of the rock is not carried on to a greater depth than about 90 to 100 feet, as below that depth it is too unproductive to remunerate the proprietor*" (Young, 1828, 137*). "The main bed of the alum shale abounds with petrifactions, consisting of wood, bones, but especially shells, among which the ammonites (the well-known Whitby* <u>*snake-stones*</u>*) hold a conspicuous place"* (Young, 1828, 137).

Cement Manufacture:

Cement manufacture was undertaken at some Yorkshire alum works from the 1810s. "*Hard nodules…which occur in almost all parts of the aluminous strata, are generally of a kind of blue limestone, combined with pyrites…*[but sometimes] *solid masses of pyrites*" (Young, 1828, 138). The nodules were a "*lenticular or discoidal shape*", flattened parallel to the rock-bedding, and four to ten inches in diameter. During the quarrying of shale for alum they were generally discarded, until a new use for low-pyrite nodules was found. "*Within the last fifteen years, the nodules have been collected att some of the alum works, to be employed in the manufacture of* ***<u>terras,</u>*** *or* ***<u>Roman cement</u>****. For this purpose, they are burnt in a kiln; then broken, and pounded with stampers, and lastly ground to powder in a mill. This powder, when mixed up properly with water, forms a durable cement. The nodules that contain much pyrite are rejected as unfit for this use*" (Young, 1828, 138).

Kettleness alum cliff collapse 1829 :

William White reported in 1840 that "*SANDSEND and KETTLENESS have extensive alum works, and are in the Lythe township…The lofty cliff at Kettleness had several large excavations, which might be entered at low water, and formed curious and romantic retreats, but in the night of Dec. 17th, 1829, after being dislocated for some days, it gave way, and the whole hamlet glided down, towards the sea. 'The terrified inhabitants, in the darkness of the night, knew not which way to run, whilst the sinking cliff pressed on them from behind, and the yawning deep threatened them before'. After many narrow escapes, they all found shelter for the night on board the Henry, a vessal lying off* [offshore] *for* [ready to collect] *alum, but their dwellings and the alum works were totally overwhelmed. The latter were restored in 1831*" White, 1840, 683)..

Kelp Alkali made at Staithes:

At Staithes, "*the inhabitants live almost wholly by fishing…In the herring season, the village generally sends fifteen vessels to Yarmouth. Besides fishing, the inhabitants here, and along the coast, during the summer months, are occasionally occupied in making kelp, which is a lixivial salt, obtained by the burning of sea weeds, and consisting chiefly of the fixed vegetable alkali, used in the process of making alum, glass, &c The sea weed is cut at low water, and when dry it is burnt in heaps, being constantly stirred with an iron rake till it becomes condensed and caked together in large masses. The number of fishermen and boys is about 400"* (White, 1840, 675).

European alum works technology in 1829: An account of the alum industry in the 'London Encyclopaedia' provides a few extra details, some being techniques used in Sweden and Germany. It shows that the technology was very largely unchanged. "*The English roche-alum is made from a bluish mineral stone, in the hills of Yorkshire and Lancshire*" (LEUD, 1829, 1, 705).

"*As* [because] *in England and Sweden this article* [alum] *is obtained from a stony substance, a previous roasting is necessary, which is performed in this manner. A floor is formed of clay beat* [pounded] *tight, on which faggots or coals are placed, and set fire to. Upon this the workmen throw, by degrees, small pieces of ore unburnt, till a stratum is formed about six inches thick. These soon take fire from their own bitumen* [carbon]*, and are then covered with a stratum of ore, already burnt and lixivated, of the same thickness; to this succeeds a layer of unburnt ore, and thus they proceed unil they form about ten strata*…[taking] *care to preserve an equal degree of heat…till the bitumen being all consumed the fire ceases of itself.*

If the ore is now examined it will be found to be of a reddish colour, from the same reasons that in placing the sulphate of iron [copperas] *in a red heat, it obtains and continues that colour, and is called colcothar… In the alum works of the English and the Germans, the roasted ore is lightly watered…It is likewise exposed for a greater or less time to the action of the atmosphere, by which the sulphur of the pyrites is more completely oxygenated, and consequently a greater proportion of alum obtained*" (LEUD, 1829, 708).

After calcining, the ore was lixivated, and the rsulting liquor boiled in leaden boilers. "*In the English works, after examining the hydrometer, if* [the liquor was*] sufficiently evaporated, the fire is taken away, and a stream of impure alkaline lixivium* [solution] *from kelp and soap-marker ashes, poured into the boiler; at the same time the cork* (sic)[stop-cock] *at the bottom is opened and the liquor run off into a reservoir, by which means a speedy and complete mixture is effected.*

It remains in this reservoir for three hours, when the alkali makes it deposite an earthy and ferruginous sediment, which is the action of cleaning it. It is then run to another vessel, and again proved [specific gravity tested], *when* [then] *a greater or lesser quantity of putrid urine is added, according as* [to how much] *it is above the standard* [correct density]; *it is briskly stirred for about a quarter of an hour, and then left to rest: in the course of five days the crystals* [are] *deposited-*

The rough alum is then washed, to free it from the green vitriol, which is deposited with it. It is boiled again and when boiling, bullocks' blood, or other such substance, is thrown in to clear it: when this is effected, the liquor is run into casks, where the crystals are deposited in large masses. After ten or twelve days the mother water is poured out, and the salt, after drying, is ready for sale" (LEUD, 1829, 1, 708).

Synthetic Soda production - Lord Dundas and Lord Dundonald :

New techniques for making **synthetic soda** from common salt and sulphuric acid were developed at the close of the eighteenth century. This was suitable for soap and glass manufacture, and the removal of heavy taxes on common salt and on sulphur imports, gave synthetic soda a rapidly growing share of the alkali market. Consequently the price of kelp ash decreased, to the benefit of alum manufacturers. Many, however, changed to using soapmakers waste for their alkali. Many improvements in Yorkshire alum industry were instigated by Lord Dundas at Lofthouse alum works (Price, 1817, 2, 812).

The availability of cheap and abundant **sulphuric acid** was necessary for the new chemical industries. Industrial sulphuric acid in the seventeenth century was made in small quantities by strongly heating copperas (ferous sulphate)and dissolving the resulting sulphur trioxide gas in water. 6 cwt. copperas gave only 64lb. acid (Clow&Clow, 1952, 131). Apothecaries often preferred to burn the element sulphur in glass containers over water. This produced both sulphur dioxide and trioxide gases, which dissolved in water to give a mixture of sulphurous and sulphuric acids respectively. Sulphurous is a weaker acid, and could not be separated out, but the mixture was adequate for preparing medicines.

Joshua Ward (1685-1761)(qv), a fashionable but unqualified quack physician in London, was the first to use a mixture of nitre (saltpetre) with the sulphur to make sulphuric acid in commercial quantities. Nitre improving the combustion and greatly reduced the proportion of sulphurous acid (Azimav, 1962, 155; Cotterill, 1991, 24). Johann Glauber (1604-1670) had devised a method of burning sulphur with nitre in the prresence of steam in the sixteenth century (Forbes, 1970, 243). In England, the idea of using nitre to improve combustion may originally have come from Cornelis Drebbel (c.1572-1633) (Williams, 1969, 542).

Ward was the son of a dyer (or possibly alum-maker) at Guisborough in Yorkshire (DNB 2004 57, 323; Williams, 1969, 542). He moved to London and worked with his brother William as a drysalter in Thames Street (TTW, 2016). In 1716 he became MP for Marlborough in a blatently fraudulent election involving forgery, and soon fled abroad to live in France for sixteen years before obtaining a pardon.

Returning to London, he opened a sulphuric acid works at Twickenham about 1736, and employed the chemists John White and F. J. D'Osterman (Forbes, 1970, 244). The works were relocated to Richmond about 1740 because of the offensive fumes, but Ward did not patent his method until 1749. Output was modest. Mortars and pestles were used to powder the nitre and sulphur, which was burned in large, fragile blown-glass containers of 40 to 50 gallons capacity (Clow&Clow, 1952, 132). Ward nevertheless became wealthy from his medicines, and other projects, accumulating about £16,000 by the time of his death.

John Roebuck (1718-1794), a qualified physician, developed his own method of using nitre and sulphur, but burned this in large combustion chambers made of lead sheets lining a wooden framework. Acid production was possible on a much larger scale. In partnership with the inventor and merchant **Samuel Garbett (1717-1803)**, Roebuck opened his first sulphuric acid works in Steelhouse Lane, Birmingham, in the early 1740s. A second, larger works followed in 1749, on the Scottish coast at Prestonpans near Edinburgh.

Sometime between 1771 and 1795 a mysterious visitor named W. E. Sheffield, made sketches and notes of the secret works at Steelhouse Lane. It is possible that the visitor was a representative of Lord Mulgrave's alum family in Yorkshire. The notebook was later discovered by Oscar Guttman and published in the 'Journal of the Society of Chemical Industry' in January 1901.

The Yorkshire alum innovator **Lord Dundas (1712 -1781),** Sir Lawrence Dundas of Kerse**,** was the younger son of Thomas Dundas (c.1681-1762), a Scottish woollen draper at Fingask (DNB, 2004, 17, 267). Lawrence began as a wine merchant, but made his fortune as an army contractor, originally as commissary for bread and forage in Scotland during 1746-8 for the Duke of Cumberland. He was later commissary for stores in Scotland over the period 1748-57, when seven batallions were stationed there and major building works were being undertaken. From 1762 he was patronized by Lord Shelburne, William Petty (1737-1805) the first Marquis of Lansdowne, who accepted large loans from Dundas. He became MP in 1762 for Newcastle-under-Lyme in Staffordshire (HMP 1754-1790 III – The Members).

William Petty, as a member of the Privy Council and former president of the Board of Trade, took a keen interest in the industries of the Birmingham area. In May 1666 he interviewed Samuel Garbett regarding the sulphuric acid works, as well as his factories making buttons and firearms, and refining gold and silver. (Cotterill, 1991, 40). Garbett cultivated Petty's friendship, and it is likely that Petty shared his knowledge about sulphuric acid with Lord Dundas.

Lord Dundas became a substantial landowner, and an industrial entrepreneur. He purchased large estates in Sligo and Fife, and in 1762 acquired both **Marske** with its alum rock and Upleatham in Yorkshire. He bought slave estates in the West Indies, on Dominica and Grenada. He built Dundas House on St Andrews Square in central Edinburgh. He was a governor of the Bank of Scotland (1764-77), and a leading promoter of the Forth and Clyde Navigation Company's canal (1768). In 1776 Dundas acquired both the Earldom estate on Orkney and the Lordship of Shetland, two important centres of kelp production for the chemical industries of northern England.

The so-called **'heavy' chemical industries** developed after it became possible to profitably change common salt (sodium chloride) into the alkaline chemical known as **'soda'** (**sodium carbonat**e). Removal of the very heavy **salt tax** accelerated these developments.

In Newcastle upon Tyne two independent chemists, William Losh and Thomas Doubleday had been experimenting with possible methods for making soda (Armstrong, 1863, 160). They separately became aquainted with the impoverished Scottish earl **Archibald Cochrane** (1748-1832)), 9th **Earl of Dundonald**, who was hoping to revive his furtunes through commercial applications of chemistry.

Lord Dundonald owned Culross Abbey estate in Perthshire, and had become Earl in 1778 after the death of has father Thomas (1691-1778) (DNB, 2004, 12, 303). The family estates were burdened with debts. He persuaded Losh and Doubleday to collaborate, possibly as early as 1785 according to Clow (Clow & Clow, 1952, 91). There is some uncertainty about the dates when different processes were used. "*Both Mr. Losh and Mr. Doubleday tried numerous plans at his lordship's suggestion"*, but after spending £1000 Doubleday seems to have withdrawn from the project (Armstrong, 1864, 160). They first tried Scheele's 1772 method, heating lead oxide (litharge) with common salt, making caustic soda and lead chloride (Haber, 195, 6). Charles Cooper, overman at Walker Colliery, later recalled that Losh used this method only during winter (Armstrong, 1864, 161) .The caustic soda (sodium hydroxide) was later "*carbonated*" to give soda, while the lead chloride was sold as a yellow pigment called Turner's Yellow.

Next they tried heating copperas (sulphat of iron) with common salt, which gave sodium sulphate. This was then "*fluxed with coal*" to give sodium sulphide, which had then to be "*carbonated with sawdust*" to give soda (sodium carbonate). That process was used successfully at Blyth alkali works. The sawdust ensured that only a small trace of sodium hydroxide was left as an impurity (Armstrong, 1864, 165). Losh sold "British ashes" containing 15 to 20 percent alkali, considered a good product at that time (Haber, 1952, 17).

A third process was "*the mutual decomposition of common salt and sulphate of potash. This operation was regularly carried on by Mr. Losh and Mr. Doubleday, whenever the price of the two potash salts allowed a profit to be made; and the chloride of potash was as regularly* [irregularly] *sold to the Yorkshire alum makers*" (Armstrong, 1860, 160)

It was known that the medical doctor **Nicholas Leblanc (1742-1806)** was experimenting to make synthetic soda in France, and at Dundonald's suggestion William Losh travelled to Paris in 1791 to gain as many details as possible (Armstrong, 1860, 161). In 1790 Dundonald had joined the brothers John and William Losh experimenting to make synthetic soda at Woodside near Carlisle (DNB, 2004, 12, 303). During 1793 they set up a soda works at Bells Close west of Newcastle, where Dundonald had a tar-distillery.

Lord Dundonald "*led the life of a perpetual fugitive, often staying incognito in lowly inns*" according to Trinder, and was also busy promoting chemical works in Shropshire. In the mid-1780s he became acquainted with industrial entrepreneurs in the **Coalbrookdale area of Shropshire** (Trinder, 1973, 227). In 1799 he approached **William Reynolds**, who made bricks and later also pottery at **Coalport,** with plans for an integrated **chemical works**. It would have used brine, pyrite (for copperas), and coal off Reynolds'own estates, to make alkali, alum, soap, glass and dyes (Trinder, 1973, 226). The works was to have been at Coalport, financed jointly by Reynolds and Dundonald, but the project did not materialize. Instead, Reynolds invested in a chemical works at Wombridge, initiated about 1799 by John Biddle, who soon also became a partner in the existing nearby glassworks (Trinder, 1973, 225).

Soda (sodium carbonate) was very much the chemical of interest at this time, but the project was short lived. Biddle copied the French process used by Malherbes and Athenias. Copperas was produced first, and then calcined with salt and coke to make sodium sulphide, dyes and soap (Trinder, 1973, 225). Dundonald may have had privilaged access to the works, but was very critical of the methods used.

Joseph Plymley in 1803 recorded no alum production in Shropshire, but found that the brine spring at **Kingley Wick**, two miles west of Lilleshall-hill (near Wellington), spouted 5000 gallons a day, and was "*now used for the making of soda, at a work established at Wormbridge, on the banks of the canal there*" (Plymley, 1803, 72). An earlier copperas works at **Wormbridge** used pyrites out of the Stinking Coal, a five foot seam of cheap coal (the fifty fifth named rock bed below the surface), sold for lime-burning and brick-making (Townsend, 1799, 170).

Mr. Dugard of Salop Infirmary described in 1803 how the copperas was made : "*At Wormbridge, near Wellington, as well as at several other collieries in the neighbourhood, martial pyrites are found in considerable quantities. After being cleared* [extracted] *from the coal (sulphurous coal) in which they are found, the lumps, which are perhaps twelve to fourteen pounds weight each, are disposed* [arranged] *in loose heaps, upon a bed, or large area, paved with bricks, and inclining from the circumference to the centre, to allow water with which the whole is repeatedly sprinkled, ultimately to flow into a large reservoir which is constructed at this place.*

The pyrites are thus exposed to the action of the air, as well as frequent waterings; the decomposition of them, produced by this process, forms sulphat of iron (martial vitriol) [copperas] *in considerable quantities, and was a few years ago evaporated and crystallized, and allowed* [considered] *to be by the customers, as pure a sulphat of iron* [copperas] *as any ever made in Great Britain. The demand for it was far greater than the work, in its infant state* [newly established] *could supply. It is now no longer carried on as a vitriol* [copperas] *manufactory; but the acid obtained from the pyrites, is wholly consumed in getting the soda from rock-salt and the brine of Kingley Wick*" (Plymley, 1803, 72). Rock salt may have been brought from mines in Cheshire. This vague description suggests that the evaporation of copperas was proving too expensive, and the acidic copperas solution was instead somehow used directly to make soda.

Tyneside interests drew Lord Dundonald away from Shropshire. In 1797 the Losh family inherited a share in a coal mine at **Walker** beside the Tyne, and opened a chemical works nearby, where a brine spring provided a source of salt (DNB 2004, 12, 303). That year, Lord Dundas joined Dundonald, the Losh brothers, and two bankers (John and Aubone Surtees) in a partnership which established the successful **Walker Chemical Company**. They avoided the government salt tax of £36 per ton by using a strong solution of brine to prepare other chemicals, without making salt crystals (DNB, 2004, 12, 303). They sold synthetic alkali to glassworks which had previously used Mediterranean barilla (plant ash) or Scottish kelp seaweed as their alkali (Clow & Clow, 1952, 100). **Barilla** was made from various species of the small, salt-parsh plant called Glasswort, such as Salsola sativa (Haber, 1952, 5; SocPUK, 1833, 253 and 261). Kelp contained only about one third as much alkali as barilla, but the supply was more reliable, and it had extra sodium and magnesium salts which were useful in glassmaking. "*The proportion of pure soda contained in a given quantity of kelp is always very small…between one and eight percent of alkali*", but unlike imported barilla it was not taxed (SocPUK, 1833, 268).

The Walker company began by "*evaporating together a concentrated solution of the brine spring and sulphuric acid; thus obtaining sulphate of soda*" (Armstrong, 1864, 161). Alternatively, around 1796, Losh would "*add ground* [powdered] *coke, or ashes, to the concentrating salt pan before the salt was formed, and use it in this damaged condition for the manufacture of sulphate of soda"* (Armstorong, 1864, 161).

His erstwhile associate was also active. "*Messrs Doubleday and Easterby, in 1808, commenced making sulphate of soda by decomposing the <u>waste salts</u> from the soap boilers, which consisted chiefly of common salt and some sulphate of soda*" (Armstrong, 1864, 161). At first they brought the waste from soapworks at Leith near Edinburgh, and also bought in sulphuric acid. In 1808-9 they built their own sulphuric acid works at Bill Quay on the Tyne, using designs copied from the St Rollox chemical works of CharlesTennant (1768-1838) in Glasgow, to process sulphur imported from Sicily.

In 1816 Losch returned to Paris, "*where he learnt the details of the present plan of decomposing sulphate of soda, which he immediately introduced in his works at Walker, and thus may be said to have been the father of the modern alkali trade in this country"* (Armstrong, 1864, 162) .

Nicholas Leblanc (1742-1806) patented his very successful **soda process** in France in **1791,** but it was similar to other methods used in Britain, where the patent seem to have been widely evaded (Williams, 1969, 317). Leblanc used a multi-stage process.

Salt was first put into the cooler section of a two-part 'reverberatory furnace', where **sulphuric acid** (oil of vitriol) was poured over it. This produced **sodium bisulphate**, and hydrochloric acid which was evaporated and vented away as waste up a chimney (Haber, 1958, 7). After two hours, the sodium bisulphate crystals were raked into the hotter part of the furnace, where they changed to **sodium sulphate (**called **'salt cake'**).

The 'saltcake' was removed, broken up, ground down, and then mixed with crushed limestone (or chalk) and small crushed coals (or charcoal). The mixture was put into a separate 'black ash furnace', again with a two stage heating in cooler and hotter sections.

The coal (carbon) was oxidized to carbon dioxide during heating, and this gas reduced the sodium sulphate to sodium sulphide. Calcium atoms, from the calcium carbonate of the limestone, then swapped places with the sodium atoms. The result was a mixture of **sodium carbonate** (soda, 34 to 43 percent of the total), and **calcium sulphide** (30 percent), with a variety of impurities, collectively known as '**black ash'** (Haber, 1952, 7; Clow & Clow, 1952, 113).

To make **'Crystal Soda'** (sodium carbonate) the black ash was quickly washed in water, leaving no time for the calcium sulphide to oxidize back to calcium sulphate. The sodium carbonate dissolved, and was then recrystallized in a pure form The calcium sulphide was worthless and dumped as 'galligu'. Alternatively, to make **Caustic Soda** (sodium hydroxide) the black ash was boiled with slaked lime. 'Slaked lime' was simply calcium hydroxide, produced by adding water to the quicklime made by calcining limestone.

Leblanc used his new technique to make alkali in France. But the Revolutionary government seized his assets in 1794 and published details of the technique, which was widely copied abroad.. Abolition of the salt tax in Britain led to the opening of many soda works through the 1820s, especially in north east England and central Scotlend.

Lord Dundas from an early date had similarly been involved in experiments to make "**black ashes"** for his alum works in Yorkshire. In 1795 he purchased an old candle-works in Scotland at Burnfoot of Dalmuir, and despite the assistance of Dundonald he lost £10,000 on unsuccessful trials. Instead, in return for employment, an inventor called Duncan Yule showed him how to make soda from soap-makers lees, previously dumped as waste. A large chemical works was then developed in Scotland at **Dalmuir** under the supervision of Dundonald (Clow & Clow, 1952, 105). Dundonald's patent of 30th May 1795 covered the manufacture of Glauber's Salt and its subsequent decomposition to sodium sulphide, which was used to make either soda or caustic-soda (sodium hydroxide) (Clow & Clow, 1952, 101).

During the first decade of the nineteenth century, chemical works producing synthetic alkali from salt opened in many towns in central Scotland (Clow & Clow, 1952, 106). These caused a fall in kelp prices after 1814.

Black ashes from the waste leys of soap making contained potassium from the plant and animal matter used to make soap, making them a suitable alkali for alum making. By 1840: "*The materials used in the manufacture of* [high quality] *white soaps are generally olive oil and carbonate of soda: the latter is rendered caustic by the operation of quicklime, and the solution thus obtained is called soap ley…*

The Spanish Soap is <u>marbled</u> by stirring into it a solution of sulphate of iron [copperas*], which is decomposed by the soap, and black oxide of iron separated into streaks and patches through the mass. The action of air converts the exterior into red oxide…*

Common household soaps are made chiefly of soda and tallow; or, if potash is used, a large addition of common salt is made to harden the soap…Soft soaps are generally made with potash instead of soda, and fish oil [whale oil]" (Brande, 1843, 'soap')

The developing heavy chemical industries made a growing impact on the alum industry. Former waste materials were increasingly recycled to make valuable by-products.

The Whitby alum works of Lord Normanby (Mulgrave), and those at Hurlet in Scotland, began to sell their '**alum slam'** (impure aluminium sulphate) to the Tyneside alkali manufacturers. Alum slam was previously just a waste material that had to be dumped. In return, the Tyneside alkali works sold **potassium chloride** back to the alum works (Clow & Clow, 1952, 104). By 1864 "*potash alum (formerly the only alum made) is now* *produced at the Loftus works, all the other* [alum] *manufacturers employing the cheaper sulphate of ammonia*" (Armstrong, 1864, 173).

"*The precipitation of iron from the aluminous liquors, by means* of prussiate of iron, *was first employed here* [at Loftus alum works] *by Messrs Lee and Co.; and the Guisbro' Alum Company have introduced an aluminous cake containing sulphate of magnesia which has been found to answer very well in dyeing certain colours,* [such] *as browns, blacks, &c., and in the manufacture of all kinds of coarse papers*" (Armstrong, 1864, 173). Magnesium sulphate was manufactured from "*the rough Epsoms, obtained from the residual mother liquors of the Yorkshire Alum Works",* and sold as the medicine Epsom salts (Armstrong, 1864, 174).

'Soda' came to have a different meaning in pouplar culture. "*SODA WATER. This common and refreshing beveridge is, as usually prepared, a supersaturated solution of carbonic acid gas* [carbon dioxide] *in water. True Soda Water was formerly prepared (and still is by some manufacturers) for medical use, chiefly* as a remedy for heartburn…and consisted of one, two or three drachma of carbonate of soda [soda], *dissolved in a pint of water highly impregnated with carbonic acid"* (Brande, 1843, 'soda water')

(**44 A)** Hurlet and Campsie Copperas and Alum Works – Scotland 1812

Copperas and later alum were manufactured in the Scottish coal mining district of Hurlet, three miles south east of Paisley, from the late eighteenth century. **Hurlet copperas works**, opened in **1753** by the Liverpool company **Messrs. Nicolson and Lightbody**, was regarded as the earliest in Scotland (Wilson, 1812, 281; Fullarton, 1845, 813).

The partners were the brothers James and Robert Nicolson, and their kinsman Adam Lightbody, who was another Nonconformist (Siddle, 2000, 109). James (1718-1773), Robert , and another brother John were Liverpool merchants like their father, but their older brother Samuel (1715-1749) had received a science education in Paris and qualified as a medical doctor at Leyden (Siddle, 2000, 109). Robert had originally served an apprenticeship as a linen draper. The Hurlet partners bought pyrite from a local coal mine at 2 ½ d. per hutch of "*200 weight*".

In 1791 the business was called 'John Lightbody & Co.' and was run by Adam's wife and his son John, living at Hurlet Park (Butt, 1967, 144). It was the only copperas works in Scotland until 1807 when another opened nearby at Nitshill (Househill) (Fullarton, 1845, 813; Butt, 1967, 144). In about 1808 William Ewing, the brother of widow Lightbody, opened Bo'ness copperas works (Butt, 1967, 144).

At Hurlet the mines penetrated downwards through a bed of limestone, and then a bed of 'schistus', to reach the coal below. The 'schistus' varied from ½ ft. to 3 ½ ft. thick, and represented the muds which had later covered the subsiding Carboniferous swampy forests that produced the coal. John Wilson described the coal mines and chemical operations at Hurlet, in his 'General View of the Agriculture of Renfrewshire' published in 1812. *"At Hurlet and Campsie* ***the aluminous schistus*** *rests on a pyritous-coal*", a variety *"of the caking or cementing quality, like that at Newcastle and Whitehaven; abounding like them in layers and nodules of pyrite"* (Wilson, 1812, 279).

The Carboniferous rocks of the Midland Valley in Scotland, including those at Hurlet and Campsie, consist of a repeating sequence, reflecting environmental changes during the time of deposition. A marine mudstone or limestone was followed by non-marine muds and sands, then coal, then more mudstone or limestone (Cameron and Stephenson, 1985, 50). The shale used for making alum was one of these marine mudstones, lying above a bed of coal, and below a marine limestone.

Pyrites for Hurlet copperas works were collected from several neighbouring coal mines. "*In the stratum of coal at Hurlet and Househill there are found considerable quantities of pyrites. These have since the year* ***1753*** *been carefully separated from the coal at Hurlet, and sold to a company established there, for manufacturing sulphat of iron or* ***green vitriol****. The price of these pyrites or copperas stones, by old contract, was 2 ½ d. per hutch, of two hundred weight. A similar establishment for manufacturing copperas was begun in 1807 at the adjoining lands of Nutshill, which is supplied with pyrites from the coal-wiork on the lands of Househill, adjoining Hurlet"* (Wilson, 1812, 26).

"*They are exposed to the weather on beds contiguous to the works; and, after gradual decomposition and washing with rain water, afford liquor, which, upon being concentrated by boiling, with a small adition of iron, produces green copperas, or sulphat of iron. The process, as carried on at Deptford in 1666* [sic], *is given by Mr. Colwall in the Philosophical Transactions for that year, and the same process is stiill employed with few alterations.*

The [Copperas] *price at Hurlet varied about ten years ago from £ 7 to £ 9 per ton; in the year 1805-6 it rose to £ 10 or £ 11, and since that period it has fallen to £5 per ton. The number of men employed at the two copperas works at this place is seven, exclusive of persons who collect the ore, and cart materials to and from the works. The quantity of coals consumed is about 750 tons, and the quantity of copperas manufactered about 400 tons, yearly"* (Wilson, 1812, 281).

Hurlet coal mine was probably worked along the coal-seam on a chequered-board pattern of square pillars to support the 'roof' (the overlying 'schistus'), alternating with interconnected square 'stalls' (empty caverns or cavities) where the coal was removed. The 'schistus' changed over time: *"though extremely hard when freshly dug, it decomposes by the action of the air".* In 1812 "*the extent of excavation or waste, in these mines, is about 1 ½ mile in length, and the greatest breadth about ¾ mile*; *the whole of this cavity is in general dry, and the temperature from 60* [deg.] *to* 63 [deg. Farenheit]. *In this situation the schistus gradually decomposes, and acquires a flaky or downy appearance"* (Wilson, 1812, 26). Where exposed for a long time it had "*a beautiful vitriolic efflorescence resembling plume alum, but seems rather a sulphate of iron than of alumine*".   Thus **native copperas** appeared **far more abundant than aluminium sulphate.**

"*Many unsuccessful attempts to prepare alum from this material were made in 1768 and 1785*", but it was not until new experiments were made in 1795 and 1796 that success was achieved (Wilson, 1812, 27). Nicholson and Lightbody from Liverpool reputedly made the first alum in Scotland. They "*prepared considerable quantities at Hurlet in 1766 and 1767; but their process being defective it was abandoned in the course of two years*" (Fullarton, 1845, 813).

In **1797** the successful **Hurlet alum works** was opened by **Macintosh, Knox & Co.**, comprising "Mr. Macintosh of Crossbasket, and Mr. Wilson of Thornly, and their partners" (Fullarton, 1845, 813). The actual **partners** were **Charles Macintosh**, his friend John Finlay (d.1802), John Wilson, and James Knox (Macintosh, 1847, 53). **Major John Finlay** of the Royal Engineers, had been stationed at the government gunpowder mills in Faversham, Kent, and had a private laboratory at home (ibid, 32). Finlay would have been familiar with the copperas industry at nearby Queensborough. He became secretary to Charles Lennox (1735-1806), F.R.S., 3rd Duke of Richmond, one time Master General of Ordnance and a founding member of the Royal Society of Arts in 1754 (DNM, 33, 361). After Finlay's death, Charles Stirling (d.1829) became a partner.

John Wilson was apparently a skilled alum operative trained at Whitby (Skillen, 1989). Charles Macintosh was an experienced industrial chemist. In 1799 he discovered a method of preparing 'dry chloride of lime' for use in bleaching, and this dyy bleaching powder (hypochlorite) was patented by his associate Charles Tennant (1768-1838) (Macintosh, 1847, 38; Williams, 1969, 346). At that time, Macintosh, Tennant**, James Knox,** Alexander Dunlop and Dr. William Couper were paartners in a Glasgow chemicals company, which set up the St Rollox works later in the year (Clow&Clow, 1952, 192). James Knox went to Ireland to demonstrate the use of bleaching powder to linen-bleachers (Clow & Clow, 1952, 193).

Chemists were aware by 1797 that there was **no native alum** in the 'schistus'. The pyrite present was changing under ambient conditions to sulphuric acid, and this reacted to give copperas. "*Native copperas…is frequently found"* in the mines. In his 'General View of the Agriculture of Renfrewshire', John Wilson explained that the acid could not make alum because "*no such combination with an alkaline can take place, for none of these substances are to be found in the mines at Hurlet*" (Wilson, 1812, 27).

Wilson was here correcting an error made by **Dr. James Miller** in his Appendix to 'William's History of the Mineral Kingdom' (Millar, 1810, vol.2). Miller had written mistakenly that sulphuric acid from pyrites at Hurlet mine "combines with the alumina of the shistus, and probably also with the alkali, yielding natural alum". Wilson stated clearly that there was no ammonia or alkali present in the 'schistus', and no native alum. He also showed that a change was occurring in the 'schistus' to provide (without further heating) the same raw material for alum production as that achieved by the calcination of shale in Yorkshire.

In 1847 the chemist **George Macintosh**, writing the biography of his father Charles, quoted all of John Wilson's account of Hurlet alum works (Macintosh, 1847, 44). Wilson was an experienced chemist and a partner in the business. At Hurlet the elevated temperatures (63 to 70 degrees Farenheit) caused the pyrite to form sulphuric acid in the 'schistus' where "*the most abundant products are the sulphats of iron and alumine, but those of magnesia and lime, are also not infrequent: and thus **the result of rapid calcination*** [in Yorkshire] ***is attained more slowly and abundantly in the lapse of years"*** (Wilson, 1812, 278). Aluminium sulphate was the key ingredient for making alum.

"*The mixed salts of iron and alumin* [in the decayed 'schistus'] *are conveyed from the mines to the works, then lixivated* [dissolved in water], *and the black insoluble residue is thrown aside to* <u>*the hill*</u>*, as that immense mass is technically termed…This* <u>*hill,*</u> *or mass of refuse, continues to undergo further decomposition, still affording a product of some value* (Wilson, 1812, 280). According to the many contemporary accounts of the early Hurlet works, **it was not necessary to calcine the shale** ('schistus'). This would have been an important cost saving compared with the Yorkshire practice of calcining shale.

John Wilson noted: "*In some places where the schistus may have lain for a very long period the decomposition is complete. When thus completely decomposed, it is a beautiful vitriolic efflorescence, resemblimg plume alum, but seems to be rather a sulphate of iron than of alumina. It appears in many instances to contain nearly equal qualities of each. The separation of the former* [copperas], *with a view to manufacturing alum, was always found difficult"* (Macintosh, 1847, 46). **Removal of the copperas** was the problem which defeated Nicolson and Lightbody.

Samuel Parkes, in his 1812 account of the operations, stated specifically that the shale was not calcined. "***Alum** is prepared near Glasgow, by Messrs Macintosh and Knox, at a much less expense than it can be made at Whitby, as it is there **found ready formed** in a state of silky efflorescence, and it only requires to be dissolved and crystallized for sale. It seems that a large quantity of aluminous schist was laid bare by the working of a coal pit, at least 200 years ago, and that the acytion of the atmosphere during this period has completely acidified it, and conveted it into a crystallizable salt*" (Parkes, 1812, 217).

The 'New Statistical Account' in 1845, described Hurlet coal pit in similar terms (NSA, 1845, 7, 154) Regarding the aluminous 'schist', "*when first exposed by the removal of the subjacent coal, it is in the form of a hard compact rock, is quarried with difficulty, and is composed for the most part of proto-sulphuret of iron, alumina, and coaly matter. Soon after the coal is removed from the pit (especially if there be little circulation of air) the inferior surface of the **schist becomes covered with an efflorescence**, which after the length of some time is found to penetrate through the whole thickness, splitting the rock into laminae, and thus rendering it easily quarried. After a still longer period of time, it falls to the bottom of the mine by its own gravity, and from its **light and spongy texture it termed <u>chaff</u>** by the workmen. It then consists of minute whitish or greenish coloured fibres of **the sulphurets of alumina and iron**. Besides these sulphurets, the Hurlet mines occasionally produce specimens of the native sulphates of magnesia and soda; the former of these in the shape of beautiful crystalline fibres"* (NSA, 1845, 7, 154).

After explaining the **difficulty of separating copperas from the aluminium sulphate**, Wilson stated: "*Many unsuccessful attempts to prepare alum from these materials were made in 1768 and 1782; but from experiments made in 1795 and 1796, it appeared that by proper application of the principles of chemistry, this operation might be effected. In consequence of these experiments, a work for the manufacture of alum was begun at Hurlet, in 1797, by Macintosh, Knox & Co.; and in 1805, similar works, on a larger scale…at Campsie in Stirlingshire*" (Macintosh, 1847, 46).

In Yorkshire, the proporting of copperas relative to aluminium sulphate in the liquid dervied from calcined shale was low. The alum could be crystallized while the copperas remained in solution. At Hurlet, the proportion of copperas in liquid from the decayed 'schist' was very high, and it was not possible to achieve a sufficient concentration of alum to be able to crystallize the alum first. Alum and copperas would crystallize simultaneously unless some of the copperas was crystallized first and removed.

The **economic recovery of crystalline alum** after this separation of some of copperas from aluminium sulphate in the mothers liquor from the decayed 'schist' was the **crucial innovation adopted by Charles Macintosh**. The dates of failed attempts to do so adequately by Nicolson and Lightbody appear as 1768 and

1782 in George Macintosh's version of Wilson's account, but were 1768 and 1785 in his original 'Renfrewshire' book.

George showed from a manuscript of 5th October, 1799, written by Charles Macintosh, that John Wilson himself had devised the successful separation method : "*that it first* ***occurred to Mr Wilson to try the addition of pure sulphate of potash*** *finely powdered, to the alum mother liquors after the separation of copperas; and which experiment was attended with entire success in the manufacture of alum*" (Macintosh, 1847, 46). Potassium chlorate was purchased from chemical works in Newcastle, at £12 to £20 per ton (Skillen, 1989).

Crystallizing copperas first, and removing it before crystallizing alum, was the reverse of the proceedure in Yorkshire. It was probably necessary because the proportion (concentration) of copperas relative to alum was very high at Hurlet, and low in Yorkshire. The subsequent use of **potash salts** to crystallize alum from a relatively weak solution, which prevented further copperas from crystallizing, was a crucial factor in commercial success. This seems to have been the **essential novelty used by Macintosh,** but not by Nicolson and Lightbody, which made the works a commercial success.

Louis Nicolas Vauquelin (1763-1829), who became professor of chemistry at the University of Paris (1809), was first to prove "*that soda* [sodium sulphate] *is of no use in the formation of alum*…[but] *if a few drops of solution of potass, or of sulphate of potass* [potash], *be added to an uncrystallizable solution of sulphate of alumine, the crystallization will immediately commence"* (Parkes, 1812, 218; Williams, 1969, 528). His account appeared in the Annales de Chimie, volume 22. Samuel Parkes recorded in 1812 that "*Muriate of potass* [potassium chloride] *has been found native in the bogs of Picardy: this salt was formerly, and is still, much used by some alum-makers to procure the crystallization of alum"* (Parkes, 1812, 220).

At Hurlet it is likely that, in order to allow the crystallization of copperas, the liquor had to be cooled , and it was uneconomical to later reheat it to achieve suffcient concentration for the alum to be crystallized out in the traditional manner. The addition of potash allowed alum crystallization from a solution that was otherwise too weak.

Judging the correct concentration (density or specific gravity) of the liquor, to achieve copperas removal before subsequent crystallization of alum, would have required considerable skill.

To achieve this accurately, Charles Macintosh invented, but did not patent, a hydrometer (or aerometer), which improved upon an earlier type by Anthony Baume (1728-1804) (Macintosh, 1847, 48). Baume was a French manufacturer of sal ammoniac, a chemical which Charles himself had made and sold in Glasgow from 1786 to 1792 (Macintosh, 1847, 17). He employed Mr. Twaddel to make the new device, which soon became popular and known as the Twaddel Hydrometer.

Charles also invented (without patenting) a more fuel-efficient furnace, the "*surface evaporating reverberatory furnace*", for "*evaporating the liquors…to the requisite specific gravity for the addition of the alkkaline substances*" (Macintosh, 1847, 48). Traditionally, the 'boiler' or evaporating pans were built directly above the furnace. Instead, Macintosh arranged the boiler so that "*the flame and hot air sweeps along the surface of the liquid…from a fire maintained at the end*". This quickly raised the liquid to boiling point, and carried water vapour away to a chimney. It was very successful in "*economizing building materials, vessels* [by reduced deterioration] *and fuel ; and its use has been generally and extensively adopted in the evaporation of fluids, in particular the manufacture of soda*" (Macintosh, 1847, 49). This is one of several examples quoted by his son George where Charles Macintosh produced improved technology without attempting to use a patent to deny its benefits to his competitors. The principles of a reverberatory furnace, however, were published as early as 1613 by Rovenson in his 'Treatise of Metallica' (Smiles, 1863, 84).

Wilson in 1812 continued: "*The lixivium* [liquor] *being next concentrated* [boiled down] *to the proper specific gravity, either copperas is first crystalized, and afterwards alum by the addition of pot-ash salts to what are termed the* <u>mother liquor</u> [to form the alum]; *or, at once the the mixed salts of alum and copperas, by a similar addition of pot-ash materials, are deposited by cooling, and the latter is separated by continued solution and crystalization"*. "*The final solution of alum for* <u>roaching</u>, *is brought to a high specific gravity, and to a high degree of heat; afterwards it is run into large vats where it continues to cool for fourteen days, and is then marketable as alum"* (Wilson, 1812, 280).

The number of men employed, in mining the alum-ore, carting materials, attending furnaces, and in the various manufacturing processes, is at present forty-seven, and their wages from 2s. to 3s. 6d. per day: 3000 tons of coals are consumed annually, and six horses are constantly employed.

The works affords a ready market for above 300 tons of pot-ash-residuum of [from] *other chemical works, such as the sulphat of pot-ash, muriate* [chloride] *of pot-ash, soapers'-salts, &c all of which are used in this manufacture. At the commencement of these works the price of alum in Glasgow was £28 per ton, but it immediately fell to £21 and has varied from that rate to £25 per ton*" (Wilson, 1812, 300). Glasgow had an extensive cloth-dyeing industry.

After quoting Wilson's account of Hurlet works, George Macintosh in 1847 chose not to provide extra "*details of the process of alum making*" (Macintosh, 1847, 45). However, he did summarize the operations : "*the lixivium, or aqueous solution from the ore, is evaporated to the proper specific gravity: copperas is then, in the first instance, crystallized out of the solution; and afterwards alum by the addition of potash salts is obtained by crystallization from what are termed the mother liquors; and the crude* [alum] *crystals thus obtained, being redissolved, and again recrystallized, alum in a state fit for the market is procured. In some descriptions* [types] *of alum ore, no sulphate of iron exists* [Footnote *Or the sulphate of iron is, in the process of burning, converted into an insoluble oxide of iron – Ed.*] *, in which case the process for the separation of copperas is dispensed with"* (Macintosh, 1847, 45)

Crystallizing copperas first, and removing it before crystallizing alum, was the reverse of the proceedure in Yorkshire. It was probably necessary because the proportion (concentration) of copperas relative to alum was very high at Hurlet, and low in Yorkshire. The use of potash salts to crystallize alum from a weaker solution, was a crucial factor for commercial success.

Like the alum makers of Yorkshire, Charles Macintosh studied the account of alum works in Sweden given by **Torbern Bergman** (qv) in his 1764 'Physical and Chemical Essays'. Bergman had stated that "*no such addition of alkaline substances*" was required in Sweden because potash was already present in the schist (Macintosh, 1846, 46). This seemed so unlikely that Charles sent his son Georrge, at the age of 17, to Sweden to investigate, in 1808. He reported his observations in letters to Charles, which were preserved and eventually published by George.

At **Haensetter alum works**, 110 miles from Gothenberg, George was shown around by the son of the owner, Mr. Van Hofstein. The ore was below a layer of limestone, only two feet below ground, and was quarried out, then calcined outdoors. A layer of pine and birch branches, was covered by "*a layer of schistus, which has* [already] *been used as fuel in the evaporating or roasting boilers*", followed by a third "*layer of new schistus*" (direct from the quarry), and "*so on in rotation*". George concluded that "*the small quantity of alkalui formed from urning the schistus with wood is sufficient for their purpose*" (Macintosh, 1847, 47).

"*After burning, the schistus is put into **steeps**, which are nearly the same as ours at Hurlet; water is poured upon it, the same water being poured upon five steeps before it is fit to use. This liquor is then run into a **settling cistern**, after remaining some time in which, it is next put into the first **boilers** for evaporation.*

*These boilers, which are of lead, are constructed in the following manner:- six of them, four feet diameter each, are built into one storey, in two rows, with three fires under them. They are made of lead, open above, and arched in the bottom, which is of cast iron. From these boilers the liquor is run into **wooden coolers**, which are very small, 3 feet long, and 2 ½ feet broad, with three wooden partitions in each.*

*The crystallized alum is afterwards **washed**, and **roached** exactly in the same manner as it is with us. Their **roaching casks** re about twic as large as ours, and require to stand about three weeks*" (Macintosh, 1847, 47).

George Macintosh next visited the **Garphyttan alum works**, owned by Mr. Westerberg, "*who received me in the most friendly manner". "I found them to be upon a much more extensive scale than those at Haensetter, and more regularly conducted. The process is, however, perfectly similar*" (Macintosh, 1847, 47). The works were only open for nine months a year, making 50 tons of alum a month. George obtained samples of the Garphyttan 'schist' and of the crystallized alum. After examining these, Charles Macintosh sent them in 1809 to George Dodds at Boulby alum works in Yorkshire, for his interest.

In both Scotland and Sweden the roaching "*casks were of a conical shape*" (Macintosh, 1847, 48). The narrow end was upmost in Sweden, but pointed downwards in Scotland. The Scottish arrangement caused impurities to be "*caught and retained upon the sides of the casks, deteriorating thereby the purity of the alum as it is crystallized".* As a result of George's observations, all the roaching casks at Hurlet and Campsie were inverted, to point upwards as in Sweden (Macintosh, 1847, 48)

"*In 1812 these* [Hurlet] *works afforded about 1000 tons of alum annually, employing about 3000 tons of coals, and consuming about 300 tons of potash materials produced at other chemical works; such as the sulphate of potash, muriate* [chloride] *of potash, soapers' salts, &c all of which are used in this manufacture*" (Macintosh, 1847, 45).

"*At the commencement of these works, the price of alum in Glasgow was L.28 per ton, but immediately fell to L.21 per ton; and although it again rose to L.25 per ton, during the war* [against France], *it is now (1846) about L.9 10s per ton"* (Macintosh, 1847, 45)

Calcining the Spent Shale at Hurlet -

All early accounts of alum making at Hurlet indicate that the **shale did not need to be calcined** in order to produce the 'mother liquor' ('alum liquor') of aluminium sulphate for making alum. Brian Skillen's 1989 study of Hurlet and Campsie works did not examine the chemical technology in any detail. However, after recording the failure of alum production by Nicholson and Lightbody, he did claim that: "It was Macintosh's speeding up of the process by heating that contributed much to Hurlett's success". This seems to refer to calcining the shale, since he gave a detailed account of calcining methods. Skillen did not state when calcining began, but the implication seemed to be about 1797 (Skillen, 1989).

In fact **calcining** was a rather later development.. It was introduced years after the works had opened, as a way of extracting extra aluminium sulphate from the old, accumulated and weathered pile of spent shale that had been dumped after already being processed once to extract the 'alumina sulphate' (Enc. Brit., 1842, 2, 573).

The calcining of such spent shale may have been practised first at Campsie. Although calcining could later have also been used to process new shale from recently worked mine 'stalls', after supplies of the well decayed shale had been exhausted from old sections of coal mines, there seems to be no evidence that this was done.

Instead, Skillen has documented the re-opening of old coal workings to recover decayed shale from their underground 'wastes'. Black Road Pit, which opened about 1823 and had closed by 1840, was reopened in 1852 to recover shale (Skillen, 1989).

. 'Red hills', of calcined shale, were reworked as aggregate for roads and housing estates in the 1960s (Butt, 1967, 144). Calcined shale developed "*a reddish colour, from the same reason that in placing the sulphate of iron* [copperas] *in a red heat, it obtains and continues that colour, and is then called colcothar"* (LEUD 1829 1, 708)

. It is not clear when calcining was first adopted, but it was probably well after 1812 (when early descriptions of the works were published) and well before 1839 when Andrew Ure compiled his 'Dictionary of Arts, Manufactures and Mines'. In his earlier 'Dictionary of Chemistry', Ure had noted that "the most extensive alum manufactory in Great Britain is at Hurlet, on the estate of the Earl of Glasgow, but he did not describe those works at all, and instead copied Richard Winter's description of the alum works in Yorkshire (Ure, 1828, 137).

Andrew Ure, as chemistry lecturer at Andersons Institution in Glasgow, was well aware of the alum techniques used at Hurlet and in Yorkshire. In his 1842 'Dictionary of Arts, Manufactures and Mines' the article on alum described general techniques, but some of these seem to be closely based on the practices at Hurlet, and include references to the calcining of shale there.

It seems likely that the Hurlet shale was deficient in carbon: The Encyclopaedia Britannica of 1842 stated that "*Slate-clay itself, at least not sufficiently impregnated with coaly matter to deserve the name of bituminous shale, is frequently employed in the making of alum. This is the case in the neighbourhood of Glasgow*" (Enc.Brit., 1842, 2, 574).

Ure explained that : "*Such alum-slates as contain too little bitumen or coal for the roasting process must be interstratified with layers of small coal or brushwood over an extensive surface. At Whitby the alum rock, broken into small pieces, is laid upon a horizontal bed of fuel, composed of brushwood; but at Hurlett small coal is chiefly used for the lower bed.*

When about four feet of the rock is piled on, fire is set to the bottom in various parts; and whenever the mass is fairly kindled, more rock is placed over the top. At Whitby this piling process is continued until the calcining heap is raised to the height of 90 or 100 feet. The horizontal area is also augmented at the same time till it forms a great bed nearly 200 feet square, being therefore about 100,000 yards of solid measurement.

At Hurlett the height to which the heap is piled is only a few feet, while the horizontal area is expanded; which is a much more judicious arrangement [but clearly required a lot more fuel].

At Whitby 130 tons of calcined schist produce on average 1 ton of alum " (Ure, 1842, 41).

"*A continual, but very low heat, with a smothered fire, is most beneficial…Even the best regulated calciningf piles are apt to burn too briskly in high winds, and should have their draught holes carefully stopped* [up] *under such circumstances. It may be laid down as a general rule, that the slower the combustion the richer the roasted ore will be in sulphate of alumina.*

When the combustion is complete, the heap diminishes to one half of its original bulk; it is covered with a light, reddish ash, and is open and porous in the interior, os that the air can circulate freely throughout the mass" (Ure, 1842, 41).

"*The lixivation is best performed in stone-built cisterns*", because moving calcined shale into and out of wooden cisterns quickly destroyd them.The resulting liquor (lixivium), by careful manipulation and recycling, could be raised "*upon an average to the sp.gr*.[density] *of from 1.09 to 1.15*" before it went to be heated to raise the concentration.

Ure favoured a two stage evaporation. Liquor first went into stone cisterns 4 to 6 feet wide, 2 to 3 feet deep, and 30 to 40 feet long, built of rammed clay, covered with flags or tiles, and enclosed below an arch of stone or bricks. A reverberatory furnace at one end sent flames air across the surface of the cisterns, to a tall chimney at the far end. Liquor from this was later transferred to "*proper lead boilers*" (Ure, 1842, 42; Ure, 1828, 452).

At Whitby the lead boiler pans were 10 feet long, 4 ft. 9 in. wide, 2 ft. 2 in. deep at one end and 2 ft 8in. deep at the opposite end. By completion of the boiling process "*the specific gravity of the liquor should be about 1.4 or 1.5, being a saturated solution of the saline matters present. The proper degree of density must vary, hwever, with different kinds of lixivia, according to the different views of the manufacturer."* (Ure, 1842, 42).

At this stage, the difference between Yorkshire and Hurlet was most obvious. "*For a liquor which consists of two parts of sulphate of alumina, and one part of sulphate of iron, a specific gravity of 1.25 may be sufficient; but for a solution which contains two parts of sulphate of iron to one of sulphate of alumina, so that* [as at Hurlet] *the green vitriol* [copperas*] must be withdrawn first of all* [before alum] *by crystallization, a specific gravity of 1.4 may be requisite"* (Ure, 1842, 42).

In the course of the final concentration of the liquors, it is customary to add some of the [recycled] *mother waters of a former process* [batch]*…If these mother waters contain much free sulphuric acid…they may prove useful in dissolving a portion of the alumina of the sediment which is always present*", making more alum (Ure, 1842, 42).

Alum crystallized before Copperas in Yorkshire:

"*As a general rule, it is most advantageous to separate, first of all, from the concentrated clear liquors, the alum in the state of powder or small crystals, by addition of the proper alkaline matter, and to leave the mingled foreign salts, such as sulphate of iron* [copperas] *or magnesia, in solution*" (Ure, 1842, 43; Kent, 1980, 40).

"*The concentration of the liquor ought not to be pushed so far as* [a concentration] *that, when it gets cold, it should throw out crystals, but* [instead a very slightly lower concentration] *merely to the verge of that point.*

The clear liquid should now be run off into the ***precipitation cistern****, and have the proper quantity of sulphate or muriate* [chloride] *of potash, or impure sulphate or carbonate of ammonia added to it*" (Ure, 1842, 43).

Sulphate of potash was "*the best precipitant*", but required "*ten parts of cold water to dissolve it*", and it worked best at higher concentration which involved the cost of heating water. "*As muriate of potash is fully three times more soluble in cold water, it is to be preferred as a precipitant, when it can be procured at a cheap rate*" . It had the added advantage of reacting with any copperas (ferrous sulphate) in the liquor, changing it "*into a muriate* [chloride], *a salt very difficult of crystallization, and, therefore* [by remaining dissolved], *less apt to contaminate the crystals of alum*" (Ure, 1842, 43).

The precise amount of alkali needed to convert all the aluminium sulphate to alum crystals, could not be calculated. The remaining liquor could contain excess alkali, or excess sulphate of alumina. Therefore, the liquor remaining from several batches of crystallization was combined in one cistern, where the excesses could react and more alum would precipitate.

Finally, the remaining liquid was run off and recycled into fresh lixivium, so that any remaining sulphate of alumina could be converted to alum. "*But, eventually, the mother water must be* [withheld from recycling, and] *evaporated, so as to obtain from it a crop of ferruginous crystals*" which were "*sulphate or muriate of black and red oxyde of iron*" (Ure, 1842, 43).

Copperas crystallized before Alum at Hurlet:

"*When the aluminous lixivia* [liquors] *contain a great deal of sulphate of iron* [copperas*], it may be a good policy to withdraw a portion of it by crystallization before precipitating the alum. With this view, the liquors must be evaporated to the density of 1.4, and then run off into stone cisterns.*

After the green vitriol [copperas] has been concreted [crystallized], *the liquor should be pumped back into the evaporating pan, and again [by reheating] brought to the density of 1.4. On adding to it, now, the alkaline precipitants, the alum will fall down from this concentrated solution, in a very minute crystalline powder, very easy to wash and purify.*

But this method requires more pans and [more] manipulation than the preceeding [method in Yorkshire], *and should only be had* ***recourse to from necessity***" (Ure, 1842, 43).

"*It compels us to carry on the manufacture of both the valuable alum and the lower priced salts at the same time; moreover, the copperas extracted at first from the schist liquors carries with it* [as an impurity], *as we have said, a portion of the sulphate of alumina* [which could otherwise make extra alum], *and acquires thereby a dull aspect* [reducing commercial value]; *whereas the copperas obtained after the evaporation of the alum is of a brilliant appearance"* (Ure, 1842, 43).

Using the single precise specific gravity of 1.4 as the benchmark for both crystallizing out the first batch of copperas, and then for judging the remaining liquor to be sufficiently concentrated to precipitate alum crystals (formed by the addition of adequate alkali and the resulting chemical reaction) without causing contamination from further copperas precipitation, would have simplified the task of the workmen. The remaining copperas in solution could be removed later, as in Yorkshire alum works.

Use of Macintosh's 'Twaddel Hydrometer' improved the accuracy of determining the correct specific gravity of the liquor. The fuel efficiency of his reverberatory furnace reduced the cost of the extra heating made necessary by this double evaporation technique, which was not necessary in Yorkshire.

Washing (Edulcoration) of Alum Crystal Powder:

"*This crystalline pulverulent* [alum] *matter has a brownish colour, from the admixture of the ferruginous liquors; but it may be freed from it by washing with very cold water, which dissolves not more than one sixteenth of its weight of alum*

After stirring the water and the alum well together, the former must be allowed to settle, and then the washing [liquid] *must be drawn off.*

A second washing will render the alum nearly pure. The less water is employed, and the more effectually it is drawn off, the more complete is the process.

The second water may be used [recycled] *in the first washing of another portion of the alum powder.*

These washings may be added [further recycled] *to the schist lixivia* [the origimal mother liquor]" (Ure, 1842, 43)

The Crystallization of Alum:

"*The washed alum is put into a lead pan, with just enough water to dissolve it at a boiling heat; fire is applied, and the solution is promoted by stirring.*

Whenever it is [completely] *dissolved in a saturated state, it is run off into the* ***crystallizing vessels****, which are called* ***roaching casks****. These casks are about five feet high, three feet wide in the middle, somewhat narrower at the ends; they are made of very strong staves, nicely fitted to each other, and held together by strong iron hoops, which are driven on pro tempore, so that they may easily be knocked off again, I order to take the staves asunder.*

The concentrated solution, during its slow cooling in these close vessels, forms large regular crystals, which hang down from the top, and project from the sides, while a thick layer or cake lines the whole interior of the cask.

At the end of eight or ten days more or less, according to the weather, the hoops and staves are removed, when a cask' of apparently solid alum is diclosed to view. The workman now pierces this mass with a pickaxe at the side near the bottom, and allows the mother water of the interior to run off on the sloping stone floow to [flow to] *a proper cistern, whence it is taken* [for recycling] *and added to another quantity of washed powder to be crystallized with it.*

The alum is next broken into lumps, exposed in a proper place to dry, and is then put into the finished bing [mound of prepared alum] *for the market.*

There is sometimes a little insoluble basic alum (subsulphate) left at the bottom of the cask. This [is recycled by] *being mixed with the former mother liquors,* [and] *gets sulphuric acid from them; or, being mixed with a little* [pure] *sulphuric acid, it is equally* [fully] *converted into alum"* (Ure, 1842, 44).

Another account of the two Scottish alum works, "*in the neighbourhood of Glasgow, managed with great skill and excellent in every respect*", appeared in the Encyclopaedia Britannica of 1842 (Enc.Brit., 1842, 2, 576). It may have been written by Thomas Thomson, chemistry professor at Glasgow University and friend of Charles Macintosh..

It differs from the 1842 account by Andrew Ure, in making no mention of the need to remove the bulk of dissolved ferrous sulphate (copperas) at an early stage, before crystallizing the alum. It does indicate, however, that the works still had a problem with copperas contamination of the alum crystals, and this required special attention.

"*We shall give you a sketch of the processes followed in these works.*

The bituminous shale and slate-clay employed are obtained from old coal-pits, which are very extensive in the neighbourhood of Glasgow. The air in these coal-pits is ***moist****, and its average temperature about 62 deg*. [F.].

The shale, having been exposed [underground] *for many years, has gradually opened up in the direction of its slaty fracture, so as to resemble in some respects a half-shut fan; and all the chinks in it are filled with a saline efflorescence in threads. The salt is white, with a shade of green; it has a sweetish astringent taste; and consists of a mixture of sulphate of iron* [copperas*] and sulphate of alumina.*

In order to obtain these salts in a state of solution, ***nothing more is requisite*** *than to lixivate* [soak] *this shale with water.*

The lixivated [waste] *ore being left* [dumped outdoors] *exposed to the weather, forms more salt, which is gradually washed out of it by the rain-water, and this water* [also] *is collected and preserved for use.*

The next step in the process is to boil down the liquid to a sufficient state of concentration. At Campsie, all of these boilers are composed of stone, and the heat is applied to the surface. This is a great saving [on costs], *as leaden vessels are not only much more expensive, but require more frequent renewal"* (Enc.Brit. 1842, 2, 576)

The next stage, according to Andrew Ure, was to precipitate and remove a large proportion of copperas, before converting the dissolved aluminium sulphate into alum. There is no mention of that proceedure in this account. It is a stage about which the Hurlet and Campsie Company may have preferred their potential Scottish rivals to remain unaware. The Encyclopaedia author may have relied to some extent on information supplied by that company.

"*When the liquid is raised to a sufficiently high temperature in the stone reservoir, pounded sulphate of potash, or muriate* [chloride] *of potash, as they can* [most cheaply] *be procured, is mixed with it; and there is an agitator in the vessel, by which it is continually stirred about. This addition* [of alkali] *converts the sulphate of alumina into alum.*

The liquid is now let into another trough, and allowed to remain until it crystallizes. In this liquid there are ***two salts contained in solution****, viz. sulphate of iron* [copperas] *and alum; and it is* ***an object of great consequence to separate them completely*** *from each other.*

The ***principal secret*** *consists in drawing off the mother liquor at the proper time; for the* ***alum is much less soluble in water than the sulphate of iron****, and therefore crystallizes first*.

The ***first crystals*** *of alum formed are very impure*. [This seems to refer to all crystals made during the first crystallization stage; the account is very cursory and possibly misleading]. *They have a yellow colour, and seem to be partly impregnated with sulphate of iron. They are dissolved in hot water, and the solution poured into troughs, and allowed to crystallize a second time*.

These ***second crystals****, though much purer, are not quite free from sulphate of iron; but the separation is accomplished by washing them repeatedly with cold water; for sulphate of iron is much more soluble in that liquid than* [is*] alum.*

These second crystals are now dissolved in as small a quantity of hot water as possible, and the concentrated liquid poured while hot into large [roaching] *casks, the surface of which is covered with two cross-beams*.

As the liquor cools, a vast number of alum crystals form on the sides and surface. The casks are allowed to remain till the liquid within is supposed [thought] *to be nearly of the temperature of the atmosphere. This, in winter, requires eleven days; in summer, fourteen or more. We have seen the liquid in a cask that had stood eleven days in summer, still more than blood-hot.*

The [cask] *hoops are then removed, precisely as in the manufacture of alum from alum-slate* ," so the casks could be re-assembled and used again (Enc.Brit., 1842, 2, 578). Further preparation of the crystals for sale was in the same as at other alum works.

"*There always remains in the boilers a yellowish substance, consisting chiefly of peroxide of iron. This is* [collected and] *exposed to a strong heat in a reverberatory furnace, and it becomes red. In this state it is washed, and yields more alum. The red residue* [colcothar*] is ground to a fine powder, and dried. It then answers all the purposes of Venetian red as a pigment. By altering the temperature to which this matter is expose*d [in the furnace], *a yellow ochre is obtained instead of a red*" (Enc.Brit., 1842, 2, 578).

Establishment of Campsie Alum Works 1805 -

Macintosh, Knox & Co. chose another coal mine containing rock strata very similar to those at Hurlet, to establish a second, larger alum works and associated chemical works **in 1805**, at **Campsie** in Stirlingshire, later known as **Lennoxtown** alum works (Butt, 1967, 146). This continued to operate until 1880 when the supply of shale was exhausted.

Patrick Graham, in his 1812 review of agriculture in that county, stated that "*Campsie has long been celebrated for the abundance and quality of its coal"*, present in a northern belt at a depth of 7 to 15 fathoms, and a southern belt, 15 to 22 fathoms down (Graham, 1812, 46). "*Between the upper stratum of limestone, which is 4 feet in thickness) and the coal, there is found uniformly a stratum of schistus or slate, from 4 to 15 feet in thickness. A white limestone, of inferior quality is found, as before, below the coal*" (Graham, 1812, 47). "*The Campsie coal contains a great* proportion of sulphur".

By 1812, "*in the immediate vicinity of Campsie, there are considerable chemical works carried on, where alum, copperas, soda, Prussian blue, &c are manufactured on an extensive scale; and in which a very large capital appears to be embarked*" (Graham, 1812, 342). Graham was assiduous in seeking details of the industries in Stirlingshire, and established that chemists were well aware that that it was aluminium sulphate, produced by the reaction of sulphuric acid with clay in the 'schistus', which provided the raw material they needed to make alum by reacting it with an alkali. He encountered suspicion and hostility to his enquiries, and expressed his "*regret that investigating the coal works…as well as in his enquiries concerning some of its great manufacturing establishments, he has experienced, for the most part, a jealousy of the object of these enquiries…Information concerning peculiar and secret processes, it would be improper to require, and unreasonable to expect*" (Graham, 1812, 50).

Fortunately he did obtain an officially approved **account of Campsie alum works, from "*a gentleman who is concerned in them*"** (Graham, 1812, 342). This may well have been Macintosh himself, or John Wilson, and the account was quoted verbatim : "*The company produces the alum and copperas from a decomposed aluminous schistus found in considerable quantity in the adjoining coal wastes. This schistus forms originally the covering or roof of the coal strata of the district, and is composed of silex, alumine, or clay, iron and sulphur; the two latter probably in a state of chemical union.*

Soon after the coal is wrought, this schistus, of various thickness, separates from a limestone stratum immediately above; thus falling down into the waste [the 'stall' cavity or cavern where coal had been removed]. In the process of time, indeed, generally after the lapse of many years, owing to a constant circulation of air through these wastes [caverns], *which being level free, are always dry (an indespensible requisite to this operation of nature) the sulphur becomes oxygenated; and is converted into vitriolic or sulphuric acid; this, uniting with the iron, forms copperas, and with clay,* [forms] *sulphat of alumine, from which crystallized alum is afterwards made.*

The decomposed schistus, as taken out of the wastes, is lixivated [dissolved in water] *and the lixivia* [solution] *evaporated. Upon cooling, pure sulphat of iron, or copperas, separates. The mother waters [remaining solution] are then boiled with a solution of sulphat of pot-ash, by which (the triple salt) crystallized alum is formed; this separates in its turn by cooling, and is purified by subsequent crystallizations.*

The making of Prussian blue, being a delicate and intricate process, although it is known that alum and copperas enter into its composition, the manipulation of this process is not divulged by the company; (the theory is no secret). Neither is that of the soda manufacture made public; for which it is presumable that the company has local facilities; amongst these, the abundance and moderate price of coal is no doubt to be reckoned" according to the unnamed representative of the company (Graham, 1812, 346: Clow & Clow, 1952, 209).

Calcining Spent Shale at Campsie Alum Works:

An unnamed chemist, quite possibly Macintosh's friend Thomas Thomson of Glasgow University, described the origin of calcining at Campsie in an article on 'Alum' for the Encyclopaedia Britannia of 1842 Thomson certainly wrote the 'Chemistry' article in that publication: "*In the alum manufactory at Campsie, near Glasgow, the alum is made from a shale taken out of the old abandoned coal-pits in the neighbourhood.*

At first this shale furnished alum by simple lixivation [soaking] with water. This process having been continued for a number of years [after 1805], *a great quantity of washed shale gradually accumulated in the neighbourhood of the works. This shale, when burnt, was found to yield a new crop of alum.*

Now, in this burnt shale thin bands of a greyish white matter ocassionally made their appearance, intermixed with portions having a yellow colour, and which are unequally distributed. The fracture is earthy; the matter is opaque, friable, and has an astringent, acid, and sweetish taste. The specific gravity is 1.887.

It occurred to the writer of this article, trhat this substance bore a considerable analogy to alum-stone *[alunite]. This induced him to subject it to chemical examination…from this analysis we see that…[it] is not the same with alum-stone; but it consstitutes an excellent article for the manufacture of alum, being highly productive; and is consequently much valued by manufacturers*" (Enc.Brit., 1842, 2, 573).

Rival Alum Works at Hurlet – 1820:

"*In 1820 the Hurlet copperas works were purchased by **Messrs. John Wilson and Son**, and converted into an extensive manufactory of alum*" (Fullarton, 1845, 813). In 1845, both of the Hurlet alum works were "*producing a large and steady supply of alum…Large quantities of muriate* [chloride] *of potash and sulphate of ammonia are also made*".

Campsie Chemical Works:

At Campsie alum works, Charles Macintosh opened "*a **manufactory of Prussian blue** (ferrocyanide of iron)"* (Macintosh, 1847, 49). This is potassium ferric ferrocyanide (Hicks, 1963, 543). Hooves, clippings off horns, hides, old woollen rags, and dried blood were calcined in iron vessels, with potash, to give a fused mass. That mass was then broken up, and dissolved in water to give a solution of *"ferro-cyanodide of potash".* The addition of copperas (iron sulphate) to that solution produced a solid precipitate of Prussian blue, and a solution of potassium sulphate.

Instead of selling Prussian blue in this form, however, it proved better to omit the copperas. Instead, the solution was evaporated to give "*large lemon-coloured crystals…which **salt** is the **prussiate of potash of commerce**"* (Macintosh, 1847, 49). Prussiate of potash had previously been made specially, from Prussian blue, and sold at 5s or 6s per ounce. The first Prussian blue made in Scotland had been in Edinburgh in 1785. by a Newcastle firm (Butt, 1967, 146). The yellow crystals from Campsie were "*salt in a state fit for the immediate use of calico-printers and dyers*". They were sold in 1835 as 2s 6d per pound, and the price fell to 1s 5d by 1846. *It is in printing and dyeing blue of various shades on cotton, woollen and silk, that prussiate of potash is chiefly employed"* (Macintosh, 1847, 50).

The fabrics were first "*prepared with a mordant, or ground of sulphate of iron* [copperas], *or acetate of iron; and after a short interval,*[they] *are then passed through a solution of prussiate of potash in water, to which a little muriatic* [hydrochloric] *acid has been added*". " *The dye rceived by the cloth is in reality…Prussian blue, resulting from the iron of the mordant* [a misnomer for 'ground'*] displacing the potash of the solution".* Charles Macintosh was the first person to suggest that calico printers and dyers could use the prussiate of potash, because of its much lower price. "*When first introduced, a solution of the salt in water*" was sold to them, instead of the crystallized salt, presumably to ensure they used it at the correct concentration. (Macintosh, 1847, 50). In 1810 some free bottles of the solution were sent to Mr. Ainsworth at his dyeworks in Manchester to persuade him to give it a try.

Large quantities of 'Prussian blue', presumably the prussiate of potash, were exported to China by the East India Company (Butt, 1967, 146).

During the year 1835-6 Messrs John Wilson & Co. mined 5701 tons of aluminous schistus at Hurlet, mainly from Haugh Pit (NSA 1845 8, 158). In the old Nicholson and Lightbody works, managed by Mr Oatts, they made 1200 tons of alum, and at Nitshill 300 tone of copperas (NSA, 1845, 8, 149 and 158). Using ammoniacal liquor from Glasqow gasworks, brought along Paisley and Glasgow Canal, then by Hurlet railway, they made large quantities of ammonium sulphate. With kelp, carried the same way, they made muriate (chloride) of potash. These chemicals, and coal, were sent out along the same route for sale in Paisley and Glasgow.

Detailed operations recorded at an unnamed alum works in 1829, by the '**London Encyclopaedia'**, may refer to Hurlet works. In parts they correspond with the description of Hurlet given by Brian Skillen (Skillen, 1989, 54). "*The stone itself is found in great quantities in some parts of the Lothians, and* *in the neighbourhood of the Hurlet works near Paisley*" (LEUD, 1829, 1, 708). "*The most extensive alum manufactory in Great Britain is at Hurlett. The next at Whitby".*

The shale rock *"is commonly broken into small pieces and laid on a horizontal bed of fuel, composed of brushwood and such like materials. When about four feet in height of the rock is piled on* [above the fuel] *fire is set to the bottom, and fresh rock continually augmented* [added] *upon the pile, until the calcined heap be raised to the height of ninety to one hundred feet.*

Its horizontal area also, at the same time, [is] *progressively extended, till it forms a great bed nearly 200 feet square, having about 100,000 yards of solid measurement. The rapidity of combustion is allayed by plastering up the crevices with moistened schist* [shale].

The calcined material is digested in water in pits of about sixty cubic yards. The liquid is drawn off into cisterns, and afterwards pumped again upon fresh calcined minerals; this is repeated until the specific gravity becomes 1.15.

The half-exhausted schist is then covered with water to take up the whole [remaining] *soluble matter and the strong liquor drawn off into settling cisterns, where the sulphate of lime, iron, and earth are deposited; and where* [if] *the liquor is boiled, its purification is acccelerated.*

It is run into leaden pans ten feet long, four feet nine inches wide, two feet two inches deep at one end, and two feet eight inches at the other. Here the liquor is concentrated at a boiling heat. Every morning the pans are emptied into a settling cistern, and a solution of muriate [chloride] *of potash, either pure from the manufacturer* [such as Tennant of Glasgow], *or crude and compound from the soap-boiler, is superadded. The quantity of muriate necessary is regulated by the workmen by the hydrometer*" (LEUD, 1829, 1, 708. The hydrometers at Hurlet were built by Twaddel, to designs by Charles Macintosh (Skillen, 1989, 54).

"*By this addition* [of muriate] *the pan liquor, which had acquired a specific gravity of 1.4 or 1.5, is reduced to 1.35, and, after being allowed to settle for two hours, is run off into the coolers to be crystallized. At a greater specific gravity than 1.35, the liquor, instead of crystallizing, would, on cooling, present us with a solid* [so-called] *magma, resembling grease. Urine is added occassionally to bring it to the proper density.*

After standing four days, the mother waters are drained off, to be pumped into the pans on the succeeding day, and the crystals of alum [left behind*] are washed in a tub and drained. They are then put into a lead pan, with as much water as will make a saturated solution at boiling point.*

When the solution is run off into casks, which at the end of ten or sixteen days are unhooped and taken asunder, the alum is found [seen] *exteriorly* [outwardly] *in a solid cake; but in the interior cavity* [exists] *in large pyramidal crystals, consisting of octahedrals successively inserted into one another. This last process* [of purification] *is called roaching*" (LEUD, 1829, 1, 709).

(45 A) The Wool Textile Industry - 'Old Draperies' and 'New Draperies'

From the fourteenth century all raw wool exported from England had to go to the Staple of Calais, where customs duties helped finance an English garrison until the town was lost in 1558 (Ramsay, 1972, 50). Individual merchants could pay the Crown for exemption from using Calais (Ramsay, 1972, 169). In 1421-2 Henry V had an income of £55,750 of which £35,000 came from wool and woollen cloth (Walling, 2014, 31). The **export duty** levied on raw wool in 1485 was over thirty percent of its value, compared with three percent on wool cloth. In 1487 much cloth making moved from Bruges to Antwerp, and to a smaller extent to Amsterdam (Smith, 1747, 79). In the 1520s and 1530s English cloth sold in Antwerp, which had superseded Brughes as leading port of northern Europe, gave a gross profit of about twenty five percent (Ramsay, 1972, 53).

Continental Europe provided a large market for wool textiles, whereas England was relatively sparsely populated. In 1545 the population of London was about 80 thousand, and the whole of England about 3220 thousand (Ramsay, 1972, 10). London was by far the main port for exports, taking business away from provincial English ports. Many resident Italian merchants deserted Southampton, and Hanseatic merchants left

Kingston-upon-Hull, to conduct business in London (Ramsay, 1972, 54). By 1546 London shipped eighty eight percent of English cloth exports.

In 1350-60 average annual exports from England included 32,000 sacks (each 364 lbs.) of raw wool and 5000 cloths. By 1538-44 this had changed to 5000 sacks and 118,000 cloths (Ramsay, 1972, 48). Most of the cloth was traditional ‘broadcloth’.

During the early fifteenth century there had been substantial and growing sales of English woollen cloth to the Baltic and southern Europe. “*About the year 1422 the Genoese obtained from the Greek emperor the lease of a hill in Asia Mnor, containing alum: England was one of the chief customers for this article*”, brought in Genoese ships (Stevenson, 1824, 309). In 1450 the alum imports for English wool fullers reached £4,000 a year, much of it entering through Bristol.

Wool prices rose rapidly in the early sixteenth century, especially in the 1530s and 1540s, became static or falling in 1570-90m and rose rapidly again in the 1590s (Ramsay, 1972, 25). Between 1543 and 1551 the silver content of English coinage was reduced by more than two thirds (Ramsay, 1972, 118). This debasement of the currency caused price inflation which boosted the wool-cloth export trade. The Stirling price charged at Antwerp rose more slowly than the fall in value of English coinage on the Antwerp Bourse (Ramsay, 1972, 67).

English merchants and clothiers tried to boost profits by encouraging extra production, but in 1550 the Antwerp market became glutted. A severe trade crisis in 1550-51 led merchants to refuse cloth from clothiers, who made their outworkers redundant (Ramsay, 1972, 67). The severity imposed on those spinners and weavers varied according to the proportion of their involvement in alternative agrarian employments. It was worst in specialist areas like Wiltshire where there were no secondary occupations in farming.

Continued fiscal deflation caused cloth prices to rise in Antwerp, preventing any quick recovery in trade. Charles V meanwhile intensified his campaign against protestant heresy on the continent, increasing the insecurity of English factors employed in Antwerp. An English statute was issued in 1552 to enforce a minimum size and weight for each of the common types of cloth, to prevent fraud (Ramsay, 1972, 90). The debased coinage was gradually recalled and replaced under Cecil’s instructions in 1560-61 (Ramsay, 1972, 169).

Antwerp itself suffered decline after the upheavals of the English cloth trade in 1551. It was the staple town of the Papal alum trade, the main centre for the Portuguese spice trade, the market for South German sales of silver and copper, and a trade centre for Italian silks, Dutch linens and Spanish wines (Ramsey, 1972, 55). But nearly one third of its imports were English cloth. The Portuguese spice trade declined in the 1550s, and in 1576 mutinous Spanish troops destroyed much of the city.

At this time English merchants actively sought and found new markets for cloth. Different types of cloth were often required. London cloth exports were severely reduced in the early 1560s and early 1570s, but stabilized after 1574 except for a sharp crisis in 1586-7 (Ramsay, 1972, 78).

Nearly all English cloth was produced under the so-called ‘**domestic system’** (Ramsay, 1972, 8). Clothiers supplied wool to spinners (making thread) and weavers who worked in their own homes and workshops. Clothiers later collected the cloth, arranged if necessary for it to be fulled and dyed, and sold it on to merchants. Some dyers and even fullers worked at home (Ramsay, 1972, 88).

Some clothiers supplied looms to their workers. Some even built workshops with looms. William Stumpe, a clothier who supplied the merchant Thomas Gresham, used the former Malmesbury Abbey as a cloth factory. Factories were unusual. John Winchcombe of Newbury reputedly housed two hundred cloth looms in one large shed, and employed a corresponding number of weavers (Ramsay, 1972, 88).

The best cloth at the beginning of the sixteenth century was traditional heavy-weight **broadcloth** made from short-fibre wool in the West Country (Wiltshire, Somerset and Gloucestershire) and Suffolk. This was exported un-dyed to the Low Countries. The early sixteenth century English dyeing and cloth-finishing industry had a bad reputation abroad (Ramsey, 1972, 49). The ‘finished’ cloth was sold onwards to markets in Germany and the Netherlands. Late in the sixteenth century broadcloth production greatly decreased when the Antwerp market declined.

Broadcloths had a statutory minimum length of 24 yards, but varied up to 30 and even 45 yards (Ramsey, 1972, 48). There was no standard broadcloth size. Of the lighter weight cloths made elsewhere, three 'kerseys' or six 'dozens' were generally regarded as equivalent to one broadcloth (Ramsey, 1972, 48). Gerard de Malynes' book '*Lex Mercatoria'* (1629), written in 1622, shows the types of English woollen cloths with their legal sizes and weights (Malynes, 1629, 42).

Coarse fabrics of long-fibre wool such as kerseys, dyed and finished locally, were sold mainly in England. Small quantities of good quality kerseys went to Italy and the Levant. The cheaper kerseys from Devon and West Yorkshire were exported undyed. Production was mainly in the northern counties. There was a sporadic increase in the quantity of coloured, English dyed and lighter weight '**New Draperies'**, including 'medley' cloth and 'Spanish cloths' made in Gloucstershire, Wiltshire and Somerset (Ponting, 1971, 26). These were sold in southern Europe and around the Mediterranean. Light weight bays and says competed against Dutch cloths in Mediterranean markets (Ramsay, 1972, 91)

A great many **varieties of wool cloth** were made, including one called 'cottons'. Peter Bowden lists the woollen cloths as broadcloth, medley cloth, kersies, dozens, penistones, friezes, cottons, and others. The worsted industry made traditional worsteds, New Draperies, and Stuffs. These included bays, says, serges, perpetuanas, rashes, frisadoes, minikins, bombazines, grograins, buffins, russells, sagathies, mockadoes, shalloons and tammies (Bowden, 2013, 41).

Kersey cloth manufacture was the main industry in Winchester in the 1530s, for export to Spain, Italy and the Levant (Page, 1912, 3, 484). Basingstoke, Romsey, Andover, Havant and Petersfield were also important kersey producers. By 1551 that industry had greatly declined, and was almost absent by 1614. The Venetians who once took large quantities of Hampshire kerseys had begun making better cloth themselves, using Merino wool (Page, 1912, 3, 485).

The treadle-powered **Saxony spinning wheel**, devised about 1530, quickly replaced traditional hand-powered spinning wheels for making yarn, but was best suited to long-fibre wool. It allowed the production of better quality light weight serges, and other 'New Draperies', since all of these contained some long-staple worsted yarn (Ponting, 1971, 31).

The **'New Draperies'** used long-staple wool, and were lighter in weight and cheaper than earlier cloths. They included worsteds, bays and says, and serges. Many were mixtures of carded woollen weft and combed worsted warp. Many of the 'New Draperies' used combinations of long-staple wool, silk, and linen yarn.

The different **staple lengths** can be seen in modern sheep. The Southdown breed has short wool fibres 4 to 6 cm. long, whereas the Wensleydale breed has long fibres up to 30 cm. long (Edwards, 2015). Each fibre is covered in tiny scales, which affects how well the fibres will lock together during fulling. The Ryeland breed has fibres 5 to 6 cm. long, but cloth made from these is very difficult to felt. The Marino breed also has fibres of 5 to 6 cm., but Merino cloth felts easily (Edwards, 2015).

Rising prosperity of the rich and middle classes in England increased domestic demand for the 'New Draperies' in the 16th century (Hill, 1969, 87).

'New Draperies' from the Devon- Somerset border and East Anglia, a traditional worsted centre, gradually came to dominate the export trade. Essex bays and says, and the serges of Devon and Suffolk became popular. Dyeing and finishing of these cloths was often undertaken in local towns (Musson, 1978, 47).

As early as 1567, **Southampton** had permitted the families of twenty skilled immigrant artisans to settle in the city to produce the 'New Draperies' of says, Spanish quilts and other cloth, rashes and serges (Page, 1912, 3, 485). To quell local complaints, the newcomers were limited to ten male servants per household. Each craft master was obliged to instruct two English apprentices for seven years, and at the end of that time they had to employ a ratio of two Englishmen to every immigrant.

By 1594 the 'New Draperies' were very successful and using large quantities of best quality English wool. Wiltshire had switched from broadcloth to 'Spanish' cloths, dyed locally, by the sixteen noughties (Ramsay, 1972, 91). In 1615 Southampton, Colchester and Canterbury were leading centres of 'New Draperies' production (Page, 1912, 3, 486). By 1618 the cloth workers of Winchester and Southampton were complaining of inadequate supplies of wool. This demand for wool, and especially long-staple wool, is reflected in Camden's 1607 assessment of the value of Isle of Wight wool.

Sheep on the Island produced suitable long-staple wool (Cheshire Weaver, 1727, 50). More details are given below in the review of 'Wool Technology'.

Fullers-earth for the finishing trade was available in Hampshire at Fuller's Bottom near Headley (Page, 1912, 3, 453).

Government controls imposed on the cloth industry supported urban centres with their guild regulations. Restrictions were placed on the activities of sheep graziers and clothiers. However, these laws were often evaded. Local Justices were often merchants, who enforced only the aspects of the law which suited them (Hill, 1969, 95).

A statute of 1533 limited the ownership of sheep by any one man to 2400. An Act of 1552 tried to restrict the activities of all wool dealers except members of the Staplers Company (Hill , 1969, 92).

The Weavers Act of 1555 prevented country clothiers from owning more than two looms, everywhere except in Yorkshire, Cumberland, Northumberland and Westmorland. Country clothiers were forbidden from owning more than one loom, thereby preventing factories being established. Weavers could not own more than two looms (Hill, 1969, 92).

The Statute of Artificers in 1563 extended guild regulations to the whole of England. For skilled crafts like weaving, apprenticeships of seven years were compulsory, and could only be provided to the sons of men earning more than £2 per year.

An Act of 1576 prevented clothiers in Somerset, Gloucestershire and Wiltshire from purchasing more than 20 acres of land (Hill, 169, 92).

As late as **1601 broadcloths**, especially those from the West Country, still represented three quarters of the value of English exports. No English merchants had the wealth, commercial acumen or complex business arrangements of their leading European counterparts (Ramsey, 1972, 81). By 1640 broadcloth exports were far less important and nearly matched in value by exports of New Draperies (Ramsey, 1972, 90).

In addition to the woollen cloths trade, wool was also used in the **hosiery trades** making knitted stockings and socks (Musson, 1981, 50). There was a widespread hand-knitting industry, usually a secondary occupation in rural areas, with particular importance in the northern counties, Yorkshire and the Lake District, as well as in Norfolk and south-west England. A stocking-knitting frame was invented by William Lee in 1589, but the framework-knitting industry remained relatively small until expanding in the late seventeenth century in Nottinghamshire, Leicestershire and Derbyshire.

(46 A) Export Trade Organizations

London merchants from various liveried companies took an early leading role in cloth exports to Antwerp. Pre-eminent were the Mercers, who gained the support of other companies including the Drapers, Grocers and Haberdashers, to organize the trade into the company of **Merchant Adventurers of London.** (Ramsey, 1972, 61). This was formalized by an Act of the Common Council of London in 1486. National and local governments found it convenient to treat with this company rather than individual merchants. It was a regulated company, meaning one where Adventurers still traded as individuals but upheld regulations imposed by the company. Adventurers sometimes cooperated by sharing ships, so each merchant reduced the financial risks from shipwreck or piracy by sending only a proportion of their cloth in each vessel.

Joint-stock companies operated a different type of organization. They obtained financing from a wide variety of wealthy individuals who did not themselves participate in the trade, or necessarily understand the business. Company directors organized trading activities in accordance with the articles of association agreed by the partners.

Both regulated and joint stock companies employed 'factors' who resided abroad at the ports they used. Factors could be the young apprentices of an English merchant, just completing their training . Many were experienced merchants who lacked sufficient capital to operate independently, and they sometimes represented various organizations on a commission basis (Ramsey, 1972, 80).

Book-keeping by merchants was haphazard. English textbooks on double-entry accounting were published from 1543, and in 1589 John Browne of Bristol published '*The Marchants Aviso'* for the training of apprentices. But the ledgers of most merchants were intelligible only to themselves and, after death, their executors often found it impossible to distinguish their assets, and money owed to them, from their debts to others (Ramsey, 1972, 81).

In 1555 the Merchant Adventurers raised their entrance fee from ten marks to one hundred (Ramsey, 1972, 89). This effectively excluded traders from provincial towns. They later restricted trade by limiting the number of cloths a merchant could export, in accordance with his standing in the company. A more monopolistic charter was obtained in 1564, but The Merchant Adventurers were unable to prevent rivals from seeking new markets for English cloth.

The **Hanseatic League** had long excluded English merchants from trading in the Baltic. Under the 1474 Treaty of Utrecht, the Hanseatic merchants had been granted lower export duties on English broadcloths than those paid by English merchants (Ramsey, 1972, 72). Their privileges were temporarily suspended in 1552. By the 1560s they had lost control over English cloth exports to north east Germany.

In 1579 English merchants from London and ports on the north east coast formed the **Eastland Company,** with a staple at Elbing, a German city on Polish territory. The staple later moved to Danzig.

In 1555 a joint-stock company of **Muscovy Merchants,** also known as the Russian Company, was promoted to find a north-west passage to the Far East. It was granted extensive trading privileges in Russia by Czar Ivan IV, and was converted to a regulated company by the 1620s (Ramsey, 1972, 72).

The **East India Company** of 1600 was a relative latecomer.

The **Gresham family** are among the best known wool cloth merchants. **Sir Richard Gresham** (c.1486-1549) served am apprenticeship to become a member of the Mercers Company in London, and began exporting cloth in 1507 (DNB 2004, 27, 519). He became a member of the Merchant Adventurers, and while Mayor of London (1537) tried unsuccessfully to promote the construction of a bourse or trading hall in the city. He became a large scale landowner and money lender. Sir William and his partner William Copeland had close commercial links with the Hoeschetter mercantile house based at Augsberg, and a member of that Augsberg family later played a key role in the Company of Mines Royal in England. **Sir Thomas Gresham** (c.1519-1579), a son of Sir Richard, served his eight years apprenticeship with his uncle, Sir John Gresham of Norfolk. After becoming a member of the Mercers Company in 1543, he lived in Antwerp as a merchant and also as an agent for Henry VIII. He became a diplomat and financial adviser to the English Crown. In 1565 he financed the construction of the **Royal Exchange in London**. He moved from Antwerp to London in 1567 and served as an adviser to Elizabeth I {Black, 1969, 48; Anderson, 1787, 2, 127).

Sir William Brereton visited "*the English house*" at Delft in May 1634. This was a 'staple' town for cloth sales. The English merchants received free food, paid no rent , and enjoyed "*a dainty bowling-alley within the court; a pair of butts; accommodated with fair, convenient lodgings*" (Brereton, 1634, 19).

(47 A) Technology in the Cloth Trade

Demand for alum in England rose during the late sixteenth and seventeenth centuries, due to the decline of the 'Old Draperies' of heavy broadcloth exported un-dyed, and the rise of light weight 'New Draperies' which were dyed and finished locally before export. The woollen textile industry was immensely important in England and it involved a complex sequence of manufacturing processes. A wide ranging, detailed review was presented to the Royal Society by **Sir William Petty** on 17th November **1661**, entitled "***Of Making Cloth With Sheeps Wool"***. It was republished in 1756 by Thomas Birch in his history of the Royal Society (Birch, 1756, 1, 55-65). Even so-called 'cotton' was a type of woollen cloth (Black, 1969, 48).

William Petty (1737-1805), Lord Shelburne, first Marquis of Lansdowne, took a close interest in many aspects of English manufacturing industry, including those in the Birmingham area (Cotterill, 1991, 39).

Raw wool was first washed inside a container immersed in a stream.

Wool processing involved the 'drawing out' of fibres ('drafting') to form yarn; twisting of the fibres to strengthen the yarn, and the 'winding-on' of fibres onto a reel or holder. The spindle and distaff technique of winding-on used a weighted and tapered spindle that rotated to twist and collect the thread.

Weaving is the technique of interlacing one sequence of threads at right angles to another sequence of threads (Ponting, 1971, 4). 'Warp' threads are held stationary, once tied in a vertical series to trees, and later in a horizontal sequence to the frame of a loom. 'Weft' threads are those being actively woven into the warp sequence.

Ancient Egyptians devised a **'heddle'** to attach the ends of each warp thread individually. By having more than one moveable **'**heddle**'** on the loom, one set of warp threads could be moved away from the other set (or several sets), creating a gap or tunnel called the 'shed', through which one warp thread could be passed in a straight line (rather that carefully weaving it in and out around individual warp threads).

A **'comb'** was then used to 'beat' the new weft thread tightly into position along the edge of the cloth being made. Another advantage of the 'heddle' was to allow the weft thread to be off a continuous spool, rather than the innumerable short lengths (each the width of the cloth) necessary to weave around the tightly packed weft threads individually.

'Worsted' was a term used from the 13th century to distinguish a particular type of wool cloth using long-staple wool. For genetic reasons, any breed of sheep can only produce one type of wool. It is either short, fine fibre wool, or else long, relatively coarse-fibre wool (Ponting, 1971, 17).

'Woollens' are made from short fibre wool. '**Worsteds**' use long fibre wool.

After being oiled (often with butter), the wool to make yarn was either **'carded'** for woollens, or 'combed**'** for worsteds (Ponting, 1921, 25).

Yarn is twisted while being drawn out (drafted) for woollens, but not for worsteds. Woven woollens are **'fulled'**, but woven worsteds are not.

'Combing' wool for worsteds was a male occupation. Short wool fibres were removed during combing.

Carding' for woollens was done by women using only the short, straight spikes of the **Teasel** plant (cardus) to mix short wool fibres into a soft thread containing fibres oriented in all random directions.

The teasels were fixed on a wooden frame or 'hand card'. By the fourteenth century teasels were replaced by metal nails protruding through leather, attached to a block of wood. **Card-making** was a common Elizabethan occupation (Ponting, 1971, 8).

Later, the cards were made using short wires instead of nails.

Wool combs had metal teeth. In the 15th century, Bristol was importing directly from Spain iron nails and wool-combs, along with alum (Carus-Wilson, 1967, 51). Steel in wool combs, also from Spain, came via Bayonne (Carus-Wilson, 1967, 37)

In 1568 the Company of Mineral and Battery Works acquired the first blast furnace in England, in order to make iron wire for wool carding. That furnace, at Tintern, had been built in 1564 by Christopher Schultz.

Women worked with a 'card' in each hand, producing a pile of wool to go onto a cleft stick called the **'distaff'**. From the distaff, wool was wound onto a weighted and tapered spindle, set spinning by hand. Modern hand-spinners prepare short-fibre fleece by carding it into rolls called 'rolags' and then spinning it in the 'woollen style' (Edwards 2015). This causes the fibres to be randomly arranged with many air spaces between fibres.

During the fifteenth century, **spinning wheels** were introduced from India or China, and replaced the distaff and spindle technique. Between 1580 and 1617 the word 'spinster' acquired its modern meaning of an unmarried woman (Hill, 1969, 83).

'Combing' for worsted yarn was designed to remove all the short fibres ('noil') and align all the long wool fibres parallel to each other. It also removed the natural crimp of the wool, causing the fibres to cling together (Walling, 2014, 39). Consequently the finished worsted cloth had a smoother surface than woollen cloth. It was also less prone to stretching than woollen cloth.

Combs had two or three rows of long, tapering, steel teeth set in a wooden handle. They were heated in a fire before use. About 2 lbs. weight of wool, already scoured and oiled, was fixed onto one stationary comb. Another comb was used manually to pull that wool progressively off the fixed comb.

Both woollens and worsteds were woven on the same type of **loom** (Ponting, 1971, 9). The width of looms increased in the 13th and 14th centuries, making broadcloth up to 100 inches wide. This cloth was a plain weave, with only two sets of warp (using two 'heddles'). The size obliged each weaver to have an assistant to get the weft thread across the full width of warp.

Smaller looms had several separate 'heddles', allowing different segments of warp thread to be raised at different times, creating a 'shed' space through which the weft passed, to give patterned cloth.

There were thus two categories of cloth, broad-loom and narrow-loom.

After weaving the cloth was '**scoured'** using the ammonia in stale human urine. This process was done by dyers or fullers. Only when short-loom cloths used dyed wool in their patterns was the scouring and dyeing done before weaving.

Woollens were then subjected to '**fulling'** (also called 'waulking'). Worsteds were not fulled. Fulling shrank the woollen cloth by squeezing it while wet. It could be done manually, by walking on the cloth, or squeezing it, or beating it with a stick. **Fullers earth** was used during fulling to remove grease from the cloth. John Hill reported in 1751 that: "*Our Fuller's Earth is a Marl of close Texture…It is frequent in Bedfordshire near Wooburn, where the greatest Quantity is dug; there are also Pits of it in Surry, and in some other counties*" (Hill, 1751, 236). Fullers-earth was available in Hampshire at Fuller's Bottom near Headley (Page, 1912, 3, 453).

Chambers's Dictionary described Fullers Earth as used *"to imbibe all the Grease and Oil necessarily used in the preparing, dressing &c of Wool. It is dug in great Plenty near Brickhill in Staffordshire; also near Ryegate in Surrey; near Maidstone in Kent; near Nutley in Suffolk; and near Wooburn in Bedfordshire*" (Smith. 1747, 475). The fullers in Holland and France, lacking Fullers Earth, instead used soap, "*scouring Clay or Potters Earth*", or urine (Savary, 1742, 2, 527; Smith, 1747, 2, 476)

After fulling the woollen cloth was stretched (or '**tentered'**) on racks to be dried outdoors. Excessive stretching gave poor quality cloth that later shrank (Ponting, 1971, 11).

Dyeing came after fulling and tentering. Dyers produced a very restricted variety of colours, each involving a complex recipe involving smelly fermentation (Ponting, 1971, 11). Woad was the main ingredient, both for blue, and in combination with weld or madder for blacks.

Raising the nap and shearing it off were the final stages of cloth production. The hooked points of teasels, set in a hand-frame, were used to manually lift the nap before shearing. For high quality cloth, this was repeated several times. **Teasels** became an object of trade. In the 14th century the export of teasels to Flemings caused a shortage in parts of England, and in the 15th century some teasels had to be imported (Carus-Wilson, 1967, 215).

"*The **Teazle, or fuller's thistle** (<u>Dipsacus fullonum</u>), bears a prickly flower-head or bur, which is used in raising the nap on woollen cloth. It is cultivated for this purpose in many parts of the west of England…In the ensuing year* [after sowing seed] *the plants bear their prickly capsules; these are in a proper state for gathering in August, when they are cut, tied up in bundles, and dried. The largest and most pointed burs are esteemed the best: they are used in dressing and preparing stockings and coverlets. The smaller kind, properly called fuller's, or draper's teazles, is used in the preparation of cloth.*

When applied for the purpose of fulling, the heads are fixed firmly round the circumference of a large broad wheel, which is made to revolve, and the cloth is held against them, whereby the herbaceous prickles raise up the nap without injuring the texture, much more effectually and securely than any artificial instrument which could be invented" (SocPUK, 1833, 176)

Urban centres like Bristol, a major cloth producer, enforced strict regulations over the activities of weavers, dyers and fullers, enforced by fines and the seizure or destruction of property. Cloth merchants also formed trade associations or guilds.

In London, wool and cloth merchants formed the Worshipful Company of Drapers in 1361, although its origins go back to 1180. It received incorporation and a coat of arms in 1438, and has been one of the most powerful organizations in the City of London.

At Leicester in 1260 the fullers' guild forbad members from using 'backhandles' on dry cloth (Carus-Wilson, 1967, 231). A 'backhandle' was used to raise the nap on cloth before shearing. It was a wooden frame about a foot long with a handle and a central upright. There were two cross-pieces set with teasels.

Teasel hooks fluffed up the surface, drawing out fibres for shearing. It was important for the cloth to be wet, so this process was usually carried out on wet cloth emerging from fulling. The cloth was hung over a wooden bar or frame called a 'perch', and raising the nap was called 'perching'.

Water power was increasingly used for **fulling** from the 13th to early 15th centuries, despite objections from traditional textile towns (Platt, 1981, 108). Some Domesday corn mills were converted for fulling.

Rural water power, often at manorial mills, broke the cloth monopolies of city craft guilds in the 14th century (Ponting, 1971, 15). Water mills led to the rise of rural textile industries in south west England (Wiltshire, Somerset and Gloucestershire), in the West Riding of Yorkshire, and East Anglia.

Raw wool was easy to transport when bagged, and could be brought from some distance to locations with water power. Consequently the dispersed, agrarian industry which developed in sixteenth century villages and towns of Wiltshire (Devizes, Warminster, Westbury, Lacock) and Suffolk (Lavenham) was quite different to the tightly regulated thirteenth century industry of Flanders, in the cities of Ghent, Ypres and Bruges (Ramsey, 1972, 85).

Over-shot water wheels fed by a millpond proved more reliable than undershot wheels which used the power of natural streams. The water wheel was attached by a cam to a shaft which raised and then released an alternating pair of hammers that pounded cloth in the pit below.

This **mechanical fulling** was more effective than manual fulling, and allowed cloth to be made broader and to be more heavily 'felted' than before, with the fibres compressed more closely together.

Heavily fulled **broadcloth** became the main woollen cloth, especially from the West of England. It was also made in East Anglia. These strongly felted broadcloths were a major English industry from the 14th to the 17th century. They were the 'Old Draperies'.

Yorkshire made relatively coarse, narrow woollen cloths called '**kersey**', and did not switch to broadcloth on a large scale until the eighteenth century, before eventually adopting extensive mechanization and eclipsing the West Country textile industry (Ponting, 1971, 35).

In 1833 "*in the county of York, many hundreds of poor weakers work at their looms at home, and when their pieces of cloth are finished take them to the public mill with their own scouring materials and there supervise the operation of fulling. This process is intended to make the cloth of a thicker and closer texture by continued beating with ponderous wooden hammers, causing the stuff to shrink…;but the desired effect will not be produced unless the cloth be entirely divested of all greasy matter; for this purpose an alkali is used, which is generally fuller's-earth, hard soap, potash* [wood ashes] *or soda. It is, however, not unusual for the poor Yorkshire weavers to save the expence of any of these ingredients by providing a cheaper substitute in fern. They send their wives and children to an adjoining common to collect this plant, which they throw into the mill with the pieces of cloth, where the alkaline juices are espressed and worked into the cloth and as good an effect* *is produced as if potash or soda had been employed* [Footnote *Parkes' Chemical Essays*]" (SocDUK, 1833, 279).

English **short fibre wool** was widely considered the best in medieval Europe (Ponting, 1971, 17). Each sheep produced about 1.5 to 2 lbs. weight of wool, less than one quarter the weight of a modern fleece. Later, the New Draperies required good quality long-fibre wools.

Because of the high European demand for English wool, the government progressively raised the tax on raw wool exports to 33.3 percent, while the tax on cloth exports was only 5 percent. Large quantities of broadcloth began to be exported un-dyed from the West Country to the Low Countries for dyeing and finishing (Platt, 1981, 105).

This was not the result of deliberate government policies. Tudor governments had no concerted policy for protecting English industry or expanding English trade (Hill, 1969, 74). Cecil actually wished to reduce cloth exports, and raised export duty in 1558. He regarded clothiers as too politically active, compared with farmers, and hoped to concentrate cloth production in the hands of wealthier manufacturers (Hilll, 1969, 74).

East Anglia made broadcloth but this was dyed and sold in England, because the region lacked enough water-power to complete the fulling process as effectively as the West Country (Ponting, 1971, 18).

Raw wool exports declined and cloth exports rose in the 14th century (Platt, 1981, 109). Cloth exports rose rapidly in the early 16th century to meet European demand by the prosperous upper and middle classes (Hill, 1969, 72).

'**Clothiers**' in the West Country organized the manufacture of cloth (Ponting, 1971, 19). They bought wool, took it to the spinners and weavers, then organized the fulling, and sent the cloth for export (usually through London).

Some **Isle of Wight wool** went to Somerset. In 1578 the bailiffs of Newport signed an agreement with Somerset clothiers, represented by Edward Shoude of Shepton Mallet, to charge them a fixed tariff on all wool purchased on the Island (James, 1896, 1, 591).

English wool was regarded as being of exceptionally **high quality** (James 1889, 590-600). Export taxes were much higher on raw wool than on cloth (Ponting, 1971, 17). William Camden claimed in 1607 that **Isle of Wight wool** "*next unto that of Lemster and Cotteswold, is esteemed best and in speciall request by clothiers, whereby there groweth unto the inhabitants much gaine and profit"* (Sutton 2004). This praise was repeated in Ephraim Chambers's influential 1728 'Cyclopaedia: or an Universal Dictionary of Arts and Sciences' (Smith, 1747, 2, 406).

The 'Dictionaire Universal du Commerce' by Jacques Savary Des Brulons (1657-1716), published in Geneva in 1741, similarly declared: "*The best English wool is that of Leominster in Herefordshire, of Coteswold in Gloucestershire, and of the Isle of Wight in Hampshire. It is so fine, that the Stuff, thereof made, comes near to Silk*" (Savary, 1741, 2, 955; Smith, 1747, 2, 421). John Smith in 1747 dismissed the silk allusion as "*silly Hyperbole*", and claimed these varieties were "*over-praised by English Writers and some others, or else undersold in the English Markets; both of which I think to be the case*" (Smith, 1747, 2, 406).

"*We must confess that the foreign Wools are far superior to the French Wool; at least, those of Spain, Portugal and Great Britain*", adimitted Savary (Smith, 1747, 2, 411). He thought "*the finest English wool comes from Canterbury…whereof they make in England the most fine and serviceable cloth…They make use of it in France for their finest cloths*" (Smith, 1747, 2, 420). Because of the heavy export duty on raw wool, English smugglers carried it abroad from the South coast on "*long Winter Nights*" (Smith, 1747, 2, 420). The practise was called **"Owling**" (Smith, 1847, 2, 320). English judges sat on wool packs (Smith, 1747, 2, 408).

Smith pointed out that in Europe by 1713, according to the 'British Merchant' publication, good English wools like those of the Cotswolds and from Wight, were "*accounted to be equivalent*" only to middle or low quality Spanish wools (Smith, 1747, 2, 137) Some English fleeces did come within Savary's definition of "*precious*", but "*as to the smaller Sheep of England, those* [fleece] *of the Coteswold, the Isle of Wight, &c….* [they] *are but light, like the Spanish*". (Smith, 1747, 2, 418). What was notable was the "*Price at which they are ordinarily sold in England* [behind the export-tax barrier]; *which is below the* [price of] *the lowest Wools of*

Spain, at Amsterdam, but even below the coarse Wools of Germany, and the yet coarser [wools] *of Tours in France"* (Smith, 1747, 2, 418).

Smith provided a table of English wool prices and export quantities from 1718 to 1744, as well as annual prices for wool from the Cotswolds and from the Isle of Wight from 1737 to 1744 (Smith, 1747, 2, 468). He was not a disinterested observer, since he favoured abolition of the tax on raw wool exports, and befleved that the Merchants of the Staple, originally, and more recently merchants and manufacturesr, were maintaining "*a Monopoly against the English Wool-Grower"* (Smith, 1747, 2, 408). The Cotswold and Wight wools were virtually identical in quality, and brought the same price from 1737 to 1745, when the Cotswold price rose more quickly because of more buyers there, operating "*with the View of sending it to France*" illegally (Smith, 1747, 2, 470).

In the early fourteenth century 'Lemster Ore', from Cistercian pastures at Tintern Abbey and Abbey Dore, was recorded as the most expensive English wool by Francesco Pergolotti, the agent acting for the Bardi house of Italian merchants and bankers in Florence (Walling, 2014, 23). The Lemster Ore was an ancient English short-woolled sheep, and poor quality ancient pastures may have favoured the fineness of its wool (Walling, 2014, 29). It was very similar to Merino wool from Spain, with fibres nearly as fine as silk (Walling, 2014, 38 & 179). Queen Elizabeth I demanded Lemster Ore wool for her hose.

In the eighteenth century, Robert Bakewell bred selectively from Leicester Long-wool sheep to create the New Leicester (or Dishley) breed, which improved meat production at the expense of wool quality (Walling, 20`14, 29). There was an increased demand for meat for growing urban markets. Cross breeding of Lemster Ore with New Leicester and other breeds of rams produced the modern Ryland breed at Leominster, with a much inferior wool (Walling, 2014, 29; Hereford, 2016).

Cotswold wool was a lustre long-staple wool (Ryder, 2001, 374). Isle of Wight wool was also a long-staple type (Cheshire Weaver, 1727, 5). High quality long-staple lustre wool was also available from the sheep around Lincoln and Stamford (Walling, 2014, 38). Long staple wool was the type needed for the New Draperies.

Earlier, in the fourteenth century, good wool was widely available. "*The best wool appears to have been grown in some parts of Wilts and Essex, in the Wealden of Sussex, in the lower lands of Hampshire, in Oxfordshire, in Cambridgeshire, and in some parts of Warwickshire. On the other hand, the wool of least value seems to have come from the extreme north of England, and from the south downs*" (Rogers, 1866, 1, 383). High quality long-staple lustre wool was also produced by sheep around Lincoln and Stamford (Walling, 2014, 38). The natural lustre or sheen was caused by a genetic change which caused the scales on each wool fibre to turn inwards, producing a smooth shiny outer edge at the surface of the wool (Walling, 2014, 38).

Owling, the smuggling abroad of raw wool, was a continual problem (Chatterton, 1912). As early as 1395 Thomas Symonde, the Rector of Freshwater on the Isle of Wight, was summoned for smuggling wool to France (Cowes Customs, 2007). 'The Cheshire Weaver' in 1727 published in London an account of the harm done to the British cloth industry by smugglers, who supplied continental cloth makers with high quality long staple wool to the great detriment of British cloth exports.

In 'Excidium Angliae', he recorded: "*And for clothing Wool, Herefordshire, Tags Wool in Rumney-Marsh in Kent, Sussex, and the Isle of Wight afford us a Wool, that for fineness and softness is but a Trifle, if at all, inferior to the Spanish Wool, but is incomparably more useful and more valuable than that, because of the Length of it, being from 1 ½ Inch to 4 Inches long, and that of Spain but from ½ Inch to 1 ¼ Inch long".* (Cheshire Weaver, 1727, 5).

"*Which Advantage, in the Length of the Wool, is the Reason that infinitely stronger Cloth, with a better Nap and Gloss, can be made of our Wool just mentioned, than can be manufactur'd of Spanish wool alone; for this Wool being so very short, cannot be spun into so strong a Thread for the Chain as our Wool, and therefore both in France and Holland they size the Warp, made all of Spanish Wool, to give it Strength*". (Cheshire Weaver, 1727,5).

Their need to use "*Size hinders the Cloth from being woven so close, as [it would be] if the Chain had been strong enough without it, and* [the size] *being Scour'd off in Fulling, the Cloth then shews it self to be not close woven, and consequently cannot be so strong, have so good a Nap, and so fine a Gloss as out Cloths, whose Chain is all English Wool, and not Siz'd".* (Cheshire Weaver, 1727, 5).

"*Now by the owling of our wool to France, Flanders, and other Nations, we enable the Manufacturers there to make much better Woolen Goods (by the Means of our Wool) than their own Wool alone is capable of*" (Cheshire Weaver, 1727, 6). This reduced their demand for English cloth.

The character of Wight wool probably changed during the later eighteenth century, when agricultural improvements resulted in a move to the Dorsetshire breed of sheep. Richard Warner reported in 1795 that: "*It is only since the introduction of the Norfolk husbandry into the Isle of Wight,* that the *sheep-farming has been attended to there; the yeomanry are now fully aware of the many advantages*" of integrating sheep with arable farming (Warner, 1795, 288). "*The sheep are fed in winter with hay and turnips*" (Warner, 1795, 292). These would have been the Old Dorsetshire breed of small, thrifty sheep. They had longer legs that Portland sheep, black lips and nostrils, and the exceptional ability to breed at any season (Walling, 2014, 177). The modern Dorset Horn sheep is a different breed, produced by selection and limited outbreeding with Somerset sheep, to icrease meat sales to London (Walling, 2014, 117 & 182). Their wool was good, but not the finest

Warner in 1795 gave very useful information on the Isle of Wight flock size and fleece weights. "*The number of sheep annually shorn is computed to amount to forty thousand*" (Warner, 1795, 289). "*The average weight of wool per fleece, in the Eastern part of the island, is three pounds; and in the Southern and Western parts, about three pounds and an half. Little of this is manufactured in the island, it being chiefly exported in the fleece to different trading towns"* (Warner, 1795, 289). Ryder shows them as the white faced horned sheep (Ryder, 2015).

Unlike the wool-trade organization of Somerset clothiers, who fetched wool from as far away as the Isle of Wight, the early 'clothiers' of Yorkshire were artisans who made the cloth themselves, with the help of assistants. Their cloth was made on a small scale, for sale within England.

During the first half of the sixteenth century, production of heavily-fulled, undyed broadcloth in Witshire, Somerset and Gloucestershire was the most important English industry, exporting almost entirely to Antwerp via London (Ponting, 1971, 21). The quality of dyeing and finishing there enhanced the popularity of plain-woven broadcloth.

The woollen cloth export market collapsed around 1550, and the crisis was increased by debasement of the English coinage (Hill, 1969, 72). New markets were found, such as Russia supplied by the Russia Company. By the end of the sixteenth century the New Draperies of lighter cloths had gained new markets around the Mediterranean and in Africa. Peace with Spain from 1604 increased commercial prosperity.

Initial wool processing involved two operations (Ponting, 1971, 31). Carded wool (for woollens) or combed wool (for worsteds) was drawn out into a 'roving', and then drawn out again into thread.

It proved impossible to complete the drawing-out in a single operation. Short fibres for woollens had to be twisted while being drawn out, to prevent the thread breaking. The old spinning wheel was well suited to this and the resulting cloth responded well to fulling.

For worsteds, the combing produced a 'top' of long-staple wool which was then drawn out repeatedly to give a sufficiently narrow thread for spinning. 'Yarn' is the term for thread after spinning

Spinning wheels originated in India or China and reached England by the 15th century. They were introduced into cloth-making areas where the industry was already established. In many homes a 'spinster' continued to use the traditional spindle and distaff to make thread for local production of the clothes worn by the family.

The original **hand-powered spinning wheel** (a 'Jersey' or 'muckle' wheel) used a cord to drive the spindle. It was best suited to making thread from short-fibre wool, held on a distaff.

The wheel was spun slowly to place a precautionary twist on the thread during the 'drafting' (drawing-out) from short-staple wool. The wheel was then spun faster to put more twist in the thread. This reduced the chances of the short-fibre thread breaking.

Finally, by changing the angle at which the thread was held manually relative to the spindle, the twisted thread (yarn) was wound onto the spindle which acted as a reel for temporary storage. Three distinct actions were involved in spinning.

The **treadle-powered Saxony spinning wheel** was devised about 1530 by Johann Jurgen, a German wood carver. The wheel rotated faster, using a foot pedal, instead of being propelled intermittently by hand. There was a novel ‘flyer’ revolving around the spindle. This acted to draw out the thread without giving it the precautionary initial twist.

The flyer then twisted the drawn-out thread, and guided it to a bobbin on the spindle for storage. Twisting of the fibres was delayed until after the initial spinning action. The Saxony wheel was better suited to long-staple wool thread than the short-staple wool thread which was liable to break..

The treadle-powered Saxony wheel allowed the spinner to use both hands to draw out the ‘top’ of combed-out long-staple wool. Because the ’flyer’ did the spinning before the twisting occurred onto the bobbin, this wheel was well suited to the long-fibre worsted thread.

It made possible much finer threads of long-staple wool. The result was a finer, lighter weight cloth which became very fashionable. The Saxony wheel facilitated the ‘New Draperies’ because all of these contained some worsted yarn.

Clothiers in the West Country changed from making heavy, un-dyed broadcloth to lighter, coloured broadcloths. These never regained the same market dominance as the earlier plain cloths. The dyeing industry was expanded.

Local knowledge of **dyeing techniques** had been maintained at centres like Stroud, with its tradition of scarlet cloth. In the seventeenth century various publications propounded a greater variety of dyeing techniques, as did immigrant cloth artisans.

Petty, the son of a Hampshire cloth merchant at Romsey, published ‘*An Apparatus to the History of the Common Practices of Dyeing’* (1662) accurately detailing the methods of Flemish and Italian dyers (Brunello, 1973, 203).

Devonshire kersey production of coloured cloths along the Devon-Somerset border developed from the mid 16th century into a major industry in the mid 17th century. It was based mainly around Taunton, Tiverton, and Exeter. Exeter was the designated export port and also undertook some cloth finishing processes.

Local coarse long-staple wool was used, but growth of the industry required wool to be brought in from some distance. Isle of Wight wool probably went there, as did wool from Ireland.

Foreign artisans may have been far less important in the development of ‘New Draperies’ in the West Country than they were in East Anglia, which also prospered (Ponting, 1971, 32).

Use of coloured yarn led to the rise of a new class of merchants, called ‘yarn badgers’, who bought the wool, organized its spinning in artisans cottages, and its dyeing, before selling it to the ‘clothiers’. Those ’clothiers’ then confined their role to organizing cloth production and sales (Ponting, 1971, 34). Some broadcloth clothiers continued to have cloth made un-dyed and arranged for it to be dyed later.

The quality of English **short-staple wool** decreased as a result of land inclosures, which allowed more sheep being kept on the same acreage (Ponting, 1971, 27). By the 16th Century England could no longer export raw wool to Italy, and the best European cloth was being made with Spanish wool instead.

A decline in broadcloth exports was amplified by the **Cokayne debacle** of **1615** (Hill, 1969, 72). After the death of Salisbury in 1612, King James sought new revenues and was amenable to a project suggested by **Sir William Cokayne** (1559/60-1626) (DNB, 2015, 12, 448; Anderson, 1787, 2, 232). He was the second son of William Cokayne of Baddesley Ensor , Warwickshire.

Sir William proposed that all cloth had to be dyed and finished before it could be exported. He would get a monopoly, organize the dyeing, and create lots of employment. The Merchant Adventurers’ monopoly over exporting undyed cloth was withdrawn, and their staple at Antwerp closed.

With the support of Eastland merchants, and his former factor William Cradock, Sir William established the New Company of Merchant Adventurers in August 1615, with its staple at Hamburg. English dyers could not handle the quantities of cloth being made.

Within months King James lost confidence in the new company. It was soon disbanded, and the old Merchant Adventurer reinstated in January 1617, but the industry was severely damaged.

Collapse of the broadcloth cloth market in Eastern Europe was intensified by the outbreak of he **Thirty Years War** in 1618. In the 1620s and 1630s, English exports were undercut by cheaper cloth made in Silesia and Poland (Hill, 1969, 87). Broadcloth exports from London fell by two thirds between 1606 and 1640.

By 1640, half of London's cloth exports were going to Spain (Hill, 1969, 73). Under James I, ten percent of export merchants handled fifty percent of the cloth leaving London. Wealthy London merchants were an important source of loans to the Crown.

Nevertheless, the cloth industry remained the main basis of English economic prosperity. By the early eighteenth century, long staple "**Combing Wool**" for the New Draperies was being widely produced.

"*The Wool of Warwickshire, Northamptonshire, Lincolnshire, and Rutland, with some Parts of Huntingdon, Bedford, Buckinghamshire, and Cambridgeshire and Rumney Marsh, with some Parts of Norfolk, have been accounted the longest and finest Combing wool. But of late Years, there have been Improvements made in the Breed of Sheep, by changing* [the type] *of Rams, and sowing of Turneps, Grass Seeds &c, and now there is some large fine combing Wool to be found in most Counties of England, which is fine, long, and soft, fit to make all Sorts of fine Stuff and Hose of* (Smith, 1747, 2, 320).

A somewhat distorted European perspective on English cloths, alum production, and the **Cokayne debacle**, is provided by the French protestant historian **Rapin de Thoyras** (1661-1725), whose monumental '**History of England'** was translated and published in English in 1733 (Thoyras, 1733, 2, 176). "*Thomas Sackville, Earl of Dorset, dying suddenly as he was sitting at the Council Table, Robert Cecil, Earl of Salisbury, succeeded him at his post. He was a Lord of great genius, and though crooked before and behind, nature supplied that defect with noble endowments of mind.*

The chief concern of Ministers was to see that the King did not want for money. He had occasion for great sums, being extremely liberal, or rather prodigal…

One of the properest means devised to procure the King money, was the nonopoly of the sale of Cloths, at the solicitation of a certain Merchant, who, in all appearance, dearly purchased his Patent. At this time, the English were not skilled in the art of dressing and dying English Woollen Manufactures. They sent them into Holland white, and the Hollanders, after they had dyed them, sent them back and sold them in England. The Merchant I just mentioned, intimating to the King and Ministry, that a great profit would accrue to England, if the cloths were dressed at home, obtained a Patent to dress and dye them, exclusive of all others. Then the king published a Proclamation, forbidding any persons to send any white Cloths abroads. Whereupon the Hollanders prohibited the importation of dyed Cloths from England. So the Merchant who obtained the Patent, not being able to sell his dyed cloths any where but in England, was forced to dress and dye only a small quantity. This raised such clamours among the Cloth-weavers that the King was obliged to permit the exportation of a certain quantity of white Cloths. At length, the Court by degrees connived at the offenders, and the Woollen-trade continued upon the same foot as before (1).

The same year, the King ingrossed to himself the selling of <u>Allum</u> , which had been lately found out in England, and prohibited the importation of foreign <u>Allum</u> by Proclamation(2).

Whether the King intended to be revenged of the Hollanders for breaking his measures with respect to the Woollen Manufactures, or only to draw monies from them, a Proclamation was published, prohibiting all foreign Nations to fish on the Coasts of Great Britain. This occassioned the next year a Treaty, whereby the Hollanders engaged to pay an annual sum for leave to fish.

(1) Alderman Cockaine, with some rich Citizens [of London], *having promised Rochester, Northampton, and the Lord Treasurer* [Salisbury], *great sums of money, they procured him a Patent for dressing and dying of Cloths, and got the King to seize into his hands the Charter of the Merchant Adventurers, for transporting of white undressed Cloths. But by reason of the Hollanders Prohibition, and Cockaine's dying and dressing cloths worse and dearer than they were*[done] *in Holland, infinite numbers of poor People lay idle, and were reduced to starving condition. So the matter fell to the Ground.*

(2) At this time Sir John Bouchier (joining with the Lord Sheffield President of the North, Sir Thomas Challoner, Sir David Fowlis, and others who had Lands in the North) brought the making of Allum to perfection in England, which with great charges had [previously] *been fetched from foreign parts, particularly from Italy; and the King took the whole traffick thereof to himself"* (Thoyras, 1733, 2, 176).

(48 A) Processes and Products Using Alum and Copperas

Coppeas for Black writing ink: Ink preparation using copperas was described in 1764 by Robert Dossie (Dossie, 1764, 6).

A gallon of boiling water was poured over one pound of powdered Aleppo galls, and left for two days in a sealed vessel. Then half a pound of powdered green vitriol (copperas) was added, and the mixture repeatedly stirred for three days. Five ounces of Gum Arabic dissolved in a quart of boiling water was then added, followed by two ounces of alum. The mixture was strained through coarse linen cloth before use.

This type of ink made from copperas and plant galls is now a serious problem for book conservation, because it gradually reacts with paper and the letters fall out (Jones, 2002, 39). At the British Library, Han Neeval and Birgit Reissland of the Netherlands Institute for Cultural Heritage have reconstructed a version of sixteenth century ink by powdering galls and mixing them into heated wine to release gallic acid. They then added pounded Gum Arabic and copperas to produce a blue-black precipitate of iron pyrogallate.

Copperas or iron sulphate was already called 'vitriol' by the ninth century, in a manuscript called *Compositiones ad tigenda* (Ball, 2002, 93). Reputedly, small quantities of natural copperas were originally obtained by scraping the surface of cave stalactites and the walls of mines (Jones, 2002, 39). Most gallic acid in the ink remained dissolved until the liquid soaked into the paper during writing, when it oxidised.

From the 12th century this ink produced a 'permanent' ink that was popular because it prevented later fraud. Over the period of a few hundred years, chemical reactions by the gallic acid may cause the formation of small amounts of sulphuric acid. This acts to hydrolyse cellulose in the paper, and sometimes eventually caused the paper to crumble.

Copperas for Gold Recovery: Gold particles in the sweepings or dust of goldsmiths' workshops, and thin gold covering small articles, could be recovered by dissolving the gold in an acid stripping solution of weak Aqua Regia, a mixture of concentrated nitric and hydrochloric acids. The gold was then precipitated out using a strong solution of Copperas (Gee, 2002, 127). In 1556 Agricola had explained the use of Aqua valens for parting (separating) gold from silver (Agricola, 1556, Book X, 439). Aqua valens was a mixture of nitric, sulphuric and hydrochloric acids (but mainly nitric acid), and was made using vitriol (copperas), saltpetre, alum and water.

Copperas for Sulphuric Acid: Concentrated sulphuric acid (known as "oil of vitriol") was made by the distillation of Copperas (hydrated ferrous sulphate, known as "green vitriol"). The heating produced sulphur dioxide and sulphur trioxide gases, which were then condensed over water into which they dissolved (Greenwood and Earnshaw, 1995, 838; Hicks, 1964, 540). Sulphuric acid could be used to make hydrochloric acid (known as "muriatic acid"), by reacting with common sea-salt (sodium chloride) (Greenwood and Earnshore, 1995, 947). Hydrochloric acid was used to "pickle" steel and other metals, removing oxide scales off the surface of the metal. Concentrated sulphuric acid was widely used to make nitric acid (known as "Aqua Fortis") by reacting with either potassium nitrate (saltpetre) sodium nitrate (called Chile saltpetre). These nitrates were found naturally as evaporates in arid regions, or as an efflorescence on soil in caves. All of the acids had a great variety of commercial uses

Fake '**Epsom Salts'** were made at the Lymington and Portsmouth salt-works on the Solent in the late seventeenth century, using sulphuric acid prepared from copperas (Page, 1912, 3, 470; Aikin, 1807, 2, 387). Dr Grew had begun preparing his popular 'Epsom Salts' in 1675 from the evaporation of natural spring water. They fetched a high price, and were exported to Europe. Over many years, Solent salt-makers sold a synthetic version of Epsom Salts under the same name. It was produced by a secret method using the bittern dregs of the salt-pans and sulphuric acid.

Alum - Variety of Uses:

The variety of possible uses for alum grew as the asupply increased. Shepherds used alum as veterinary medicine. John Dyer noted that if a sheep had gouty 'halt', shepherds would "pour into their cloven feet; Corrosive drugs, deep-searching arsenic; Dry Allum, verdigris, or vitriol keen " (Dyer, 1757, I, 18).

"Alum Water, a composition used by those who colour prints, &c…take three ounces of alum, and boil it in a quart of rain or river water, till the salt is dissolved…With this water they wash their prints in order to prevent the colours from sinking into the paper, and give them a brightness which they would otherwise want" (Croker, 1764, 'alum water')

Bergman recorded a wide spectrum of uses for alum in 1784*. "In the dispensatories* [pharmacies] *alum enters many preparations, liquors, collyria, gargles, plaisters, boluses, pills, powders, and others: by its mild acidity it coagulates milk; and it, besides, possesses a remarkable astringent power.*

In the arts, also, and in the oeconomy of private life, the use of his salt is very frequent; it is added to tallow to make candles hard. The printers' cushions are rubbed with burnt alum that the ink may stick; and for the same reason the instruments used for printing linen. Wood sufficiently soaked in alum does not easily take fire; the same is true of paper impregnated with it; which for that reason, is very proper to keep gun-powder, as it also excludes the moisture of air. Paper impregnated with alum is useful in whitening silver and silvering brass without heat; it is useful, added to milk, which does not easily separate its butter; in the conglutinating of several substances; in making the pyrophorus; in tanning; and in many other manufactures.

In the art of dyeing it is particularly useful, in the preparation of the matters to be dyed; forby cleaning and opening the pores upon the surface by a gentle corrosion, it both renders the substances fit for receiving the colouring particles (by which the alum is generally decomposed) and at the same time makes the colour fixed.

It constitutes the basis of crayons, which generally consist of the earth of alum, finely powdered and tinged for the purpose. This it is which, in the preparation of Prussian blue, prevents the basis of the martial vitriol, which is soluble in acids, from being precipitated by the superfluous alkali …[The*] very white earth of alum, also, according to its quantity, dilutes the darker colours, even black itself, and produces infinite degrees of intensity"* (Bergman, 1784, 337).

By 1829 the 'London Encyclopaedia' listed the increasing number of uses made of alum: "*Alum is also of use in tanning, which it assists in restoring the cohesion of* [substandard] *skins almost entirely destroyed by lime. Vintners fine down their wines, &c with alum; fishers use it to dry cod-fish with; and bakers have mixed it with flour to make their bread compact and white; to this last use of it great objections have been made, but unjustly, for it is entirely innocent. Alum…if added in a very smmall quantity to turbid water, renders it perfectly limpid, without any bad taste or quality"* (LEUD, 1829, 1, 709).

Alum and copperas were used as **mordants**, during the process of dyeing textiles, hats and ivory.. Dyeing and leather dressing using alum are described in later sections, below.

(49 A) Cloth Dyers, Craft Guilds and Dyeing

Flemish weavers introduced new techniques in England in the 12th century, and introduced **trade guilds** to control production (Smith, 1747, 2, 74). The first guilds of weavers and of fullers were at Winchester in 1131 (Bense, 2013, 13). Weavers were often called Sarazins or Sarazinois, and may have copied Spanish methods.

Industry was based in towns. Through the 13th century urban weavers and fullers organized separate local craft guilds to promote their own interests. Guilds imposed regulations to uphold the quality of goods produced by their town, to uphold its reputation in external trade.

Dyers did not have a separate guild, but joined with other town traders in merchant guilds which sought civic charters and privileges, and sometimes enforced monopolies over dyeing over a wide rural area around their town (Carus-Wilson, 1967, 225). This later caused considerable tension between urban and rural artisans, particularly when water-powered processes favoured relocation of crafts into the countryside (Platt, 1981, 108).

Many English towns had established **dyeworks** by the 13th century (Carus-Wilson, 1967, 214) Dyers operated the only English trade that required considerable interaction with foreign countries (Carus-Wilson, 1967, 222). In 1308 the tolls to be charged on goods carried over the bridge at Werington (Warrington) in Lancashire included a half-penny on every hundred-weight of verdigris, copperas, argil or alum (Beaumont, 1872, 138).

Dyeing required technical skill, and dyers were men of substance and influence, taking on the role later played by clothiers. They had close contacts with foreign merchants to buy dyes and sell cloth, and often organized the whole cloth production process, by acting as merchants and entrepreneurs, and hiring servants to do the dyeing.

In 1553 a treatise on political economy and the importance of developing a high quality dyeing industry was presented to Edward VI (1537-1553) by **William Cholmley** (d.1544) (DNB, 2004, 11, 506). Cholmley was a London grocer specializing in spices. He lived at Southwark, but was not a member of the Grocers Company, a trade guild, and was probably unrelated to Sir Hugh Cholmley (1600-1657) who was active in the later Yorkshire alum trade.

William's thesis centred on the supposed loss of coin from the realm due to the lack of a high quality cloth-finishing industry, which meant that good finished-cloth had to be imported. He urged the king, and the Mayor and aldermen of London to enforce high quality standards of dyeing in the city. He expected this to attract foreign cloth-buyers, and to create a growing industry with increased employment (Cholmley, 1553).

The idea was taken seriously. Cholmley had already shown that good dyeing could be achieved. He had employed an expert dyer from Antwerp, and entered into a ten year partnership with a Southwark dyer. Using Thames water, they had experimented and eventually produced colours as good as in Flanders and France. There are no further records of his activities, but his sons William and Henry both joined the Grocers Company.

Plants for making dyestuffs were grown in England, but considerable quantities were also imported, along with alum.

Woad (waida, gaida) was the most important dyestuff, used both for blue colour and as a foundation for other colours. Picardy woad was imported into England from Amiens, Corbie, Nesle and the Somme region (Carus-Wilson, 967, 216).

In 1237 Picardy merchants secured an agreement with the City of London to establish a warehouse, and to sell dyes both in the city and at the great fairs of St. Ives (East Anglia), Winchester and Boston. In 1268 woad merchants from Amiens and Corby were allowed to live and trade in Norwich.

In the 15th century casks full of dry balls of woad often made up the entire cargo of ships trading from Bordeaux to Bristol (Carus-Wilson, 1967, 36). Alum and potash travelled the same route.

Madder (garancia, warancia) was used as a dye, and when mordanted with alum gave a tomato red colour (Carus-Wilson, 1967, 218). It was grown in England and also imported from western and southern Europe. Thomas Pennant wrote in 1787 that madder was "*first cultivated in England in the year 1597; but it grows wild in many places*" (Pennant, 1801, 1, 96). The herbalist Gerard had found it wild at Bristol. In 1660 the 'alum farmer' Nichoas Crispe was the first to grow it in Kent, at Dartford. In the 1780s it was being harvested at Dartford and Bristol. "*The process of cultivation, drying the roots, and preparing them for the dyers is amply given…*[in] *Miller's Gardener's Dictionary. The great use is the dyeing of reds and violets*" (Pennant, 1801, 1, 96).

Philip Miller, the gardener at Chelsea Botanic Garden, recorded in 1754 three species of Rubia – Madder (1) Rubia tinctorum sativa. C.B.P. Cultivated dyers' madder; (2) Rubia sylvestris aspera, quarsylvestris Dioscoridis. C.B.P. Wild Madder; (3) Rubia sylvestris Monspesulana major. J.B. Great wild Madder of Montpelier. Unlike the later authors, he stated unambiguously that "*the two Sorts of wild Madder are of no Use"* (Miller, 1754, 3, Rubia). Rubia tinctorium was "*formerly cultivated in divers Parts of England, for the Dyers use; but of late Years it has been wholly neglected…the Consumption of it in England is pretty large…*[costing] *upwards of 30,000 L. annually….the greatest Quantity of it is cultivated in Flanders and Holland"*, and imported (Miller, 1754, 3, Rubia).

Miller had visited the madder producers in Holland, where "*they pared off the outside Rind of the Roots*", to be dried and sold as Mull-madder at 16 shillings per hundredweight. "*Then they pared off another fleshy Part of the Root"*, to make Madder Number 0, sold at £2 per hundredweight. The "*Inside or Heart of the Root, is called Crop-Madder*" and was the best quality, fetching £5 per hundredweight. Miller gave advice on how to grow Dyers Madder in England..

Other red dyes came from Brasil (brasillum, bresil, brisell) from the East Indies tree *Caesalpina sappaw*, which was also widely used in India and Persia.

'Grain' (granum) was the western Europe name for the most expensive red dye (Carus-Wilson, 1967, 211 & 219). It was used in France from prehistoric times, and Kermes was the origin of the words 'crimson' and 'carmine'.

This red dye should not be confused with the extremely expensive and poisonous brilliant red pigment used by artists and called 'vermillion', which contained the powdered ore of mercury, known as 'cinnabar' and consisting of compound mercury II sulphide.

'Grain' dye was made from the wheat-like dried bodies of female scale-insects of the species ***Kermes vermilio*** Planchon 1864 (mistakenly called *Kames ilias* Linaeus 1758 or *Coccus ilias* by some historians*)*.

These insects live on oak tree sap, especially that of the Holm oak, *Quercus ilex* Linnaeus (sometimes called Kermes oak) growing around the Mediterranean (Pellizzari, 2012, 36). The female scale-insects looked like plant-galls, and grew to 7 mm in diameter. They were collected annually in March when full of eggs.

'Grain' dye was the main export from Portugal to England in the 15th century (Carus-Wilson, 1967, 60). Textiles were "dyed in the grain". Luxury woollen cloths were dyed red in kermes alone. Other woollen cloths could be dyed first to a blue colour using woad, and then in kermes to give a colour ranging from black and grey to brown or purple.

Kermes is not the same red dye as the 'kermitz' made in Persia, which was made from the Armenian 'cochineal' insect species Porphyrophora hamelii.

American cochineal dye, used since antiquity by Aztec and Mexican indians, was made from the insect *Dactyloppius coccus* Costa 1829. The insect lived on cactus ('prickly pear'). Cochineal dye superceded 'grain' (kermes) in the sixteenth century because it produced a similar colour and quality as kermes, with tin-chloride mordant, using less than one tenth the amount of dyestuff.

Specimens of cochineal were taken to Spain in the 1520s, and by the 1540s Spain was supplying the dye to Antwerp (Hage, 2010). Around 1620 largee areas of Yucatan were planted with cactus, and cochineal dye became a major export from Mexico to Spain.

Verdigris and copperas are mentioned in many murage records, a local tax for repairing town walls, including those for London (1257 and 1279) and York (1284). They were probably used in the thirteenth century as mordants, but also for sheep-dressing (Carus-Wilson, 1967, 222). 'Verdigris' was a corruption of 'vert de grise' (Agricola, 1556, Book X, footnote 4).

Verdigris was applied after dyeing to fix the colour. Copperas acted both to deepen the colour and to fix it. Verdigris is the green colour produced by weathering of copper or brass outdoors. Rain produces a patina of copper carbonate, and the presence of salt gives copper chloride.

Verdigris for dyeing in the sixteenth century was made by exposing copper to vinegar (acetic acid) in a container. This produced copper II acetate, in a mixture with other salts, and this was the most vibrant green available up to the nineteenth century. Suitable acetic acid came from the distillation of wood (Mokyr, 2003, 397)

Argol, the crude 'cream of tartar' prepared from a hard crust which coated the inside wall of vessels used to ferment wine, was used to brighten the colour of dyes and a toll was charged on it at London and York in the late 13th century.

Gerard de Malynes' book '*Lex Mercatoria'* (1629), written in 1622, shows the types of English woollen cloths with their legal sizes and weights (p.42), and the appendix has an essay called '*An Easie Partable Account between Three Dyers: which may serve as an Introduction to Beginners and, being well understood, affords sufficient variety and knowledge for the Stating of Accounts of most Partnerships'*. The hypothetical dyers "*enter into an equal Copartnership*" on 15th January 1664, each bringing particular assets and goods. Adam Barker held the lease of a dyehouse (at £100 per year), and owned utensils incuding coppers, ironware and plumbing (valued at £234). The works had stores of hay, weld (a dye plant), soot, alder-bark, and galls (collectively valued at £10). Charles Doble had 3 tonns of Allom (at £ 25 per ton), 1 tonn of Brazil wood (£28), 100 lbs. of Cochineal (at 30s per lb.), 3 hogsheads of Copperas (£8), 16 bales of Crop Mather (£340), and 18 cloths of Fustick (at 6s 8d). Edward Franklin had 10 bales of Shumak (£56) and 4 tonns of woad (£60). During the following year they spent £100 on three casks of Spanish Indico.

Malynes demonstrated how to keep a '*Wast-Book'* of the Partable Account, recording the date of every transaction made by the partners. It showed which partner bought what raw materials, and the price paid. For sales it showed the quantity of cloth dyed, the name of the customer, and how much they paid. Malynes demonstrated how to summarize and balance the accounts near the end of the year, on 29th December 1665, when their calculated profits were £497. The following essay was '*A Controversal Accompt, partable between three merchant's* itemized the goods they could purchase in England. It began with broadcloths from Simon Segerstone, clothier, and included 20 Yorkshire Gall-Blacks each 28 yards long (at £10 each).

Various recipes are extant showing the dyes used for wool. The '*Dictionarium Rusticum & Urbicum'* of 1704 provided a simple method (Anon, 1704). "*To dye it Black, bruise two pounds of Galls, and with them boyl half as much of the best green Copperas in two gallons of running Water, into which, put the Wool and boyl it; so done, take it out and dry it".*

A more complex way of producing an ash colour was provided in 1764 by *The Complete Dictionary of Arts and Sciences* (Croker, 1764). *"To dye Cloth &c Ash Colour, [for] a piece [of] 15 Ells [size]. First dye it ashy colour with Woad & Indigo, then rinse it out clean & dry it, then apply the following Black; take 4 oz. of Beaten Galls, one drachm of burnt Alum, half a pound of green Vitriol; boil & dye the Stuff in it for half an hour, then pass it thro & rinse it; then add to the Suds, 3 0z. , 3 oz. of Brash that have been before boil'd in part, three Quarts of sharp Lye, half an oz. of rock Salt, or Sal Gemma, and you will have a beautiful Ash colour."*

Dyeing Hats: "*Dyeing of hats is done by boiling a hundred pounds of logwood, twelve pounds of gum* [arabic], *and six pounds of galls, in a proper quantity of water for some hours; after which about six pounds of verdigris, and ten pounds of green vitriol* [copperas] *are added, and the liquor kept simmering, o r of a heat a little below boiling. Ten or twelve dozen of hats are immediately put in, each on its block, and kept down by cross-bars for about an hour and a half; they are then taken out and aired, and the same number put in their room; the two sets of hats are then dipped and aired alternately, eight times each; the liquor being refreshed each time with more ingredients, but in less quantity than at first. This process affords a very good black on woollen and silk stuffs as well as on hats*" (Rees, 1819, 12 Dyeing).

Dyeing Ivory: "*Dyeing of bone, horn or ivory. Black is performed by steeping brass in aqua fortis* [nitric acid] *till it be turned green; with this the bone, &c, is to be washed once or twice; and then put in a decoction of logwood and water, warm. Green is begun by boiling the bone, &c, in alum-water; then with verdigris, sal ammoniac* [ammonium chloride], *and white wine vinegar, keeping it hot therein until sufficiently green. Red, is begun by boiling it in alum-water, and finished by decoction in a liquor compounded of quicklime steeped in rain-water, strained, and to every pint an ounce of brazil wood added; the bone, &c, to be boiled therein until sufficiently red*" (Rees, 1819, 12. Dyeing).

(47 A) William Petty – The English Dyeing Industry in 1661

Sir William Petty (1623-1687) made a serious attempt to record and understand the techniques and secrets of the dyeing industry (DNB, 2004, 43, 948). Petty had trained in science, served as an army physician in Ireland and became an anatomy instructor at Oxford University. Born into a family of clothiers, at Romsey in Hampshire, he became a secretary to Thomas Hobbs, and later a surveyor employed by Oliver Cromwell to accurately measure lands confiscated in Ireland.

He became involved in developing theories about practical economics. He published a '*Treatise of Taxes and Contributions'* (1662), and described the benefits of specialization and division of labour in '*Political Arithmetick'* (1690). His 1661 account of dyeing was the first original account of that industry in English (Bancroft, 1814, 1, xxv).

Possibly the earliest English account of dyeing was in 1605, when Thomas Purfoot published the translation of a Dutch book : ' *A Profitable Booke, declaring divers approved remedies to take out spots and stains in silkes, velvets, linnen and woollen clothes; with divers colours how to <u>die</u> velvets, and silkes, linnen, and woollen, fustian and thread; also to dress leather and to colour felles. Taken out of Dutch and Elglished by L.M.*' (Bancroft, 1814, 1, xxiv).

William Petty, with his logical, analytical approach, questioned the validity of some procedures used in dyeing, and presented his detailed findings to the Royal Society in April 1661 (Birch, 1756, 83). The account was sufficiently important to be republished in full by Thomas Sprat in his 1667 '*History of the Royal Society'* (Sprat, 1667, 284 - 306). It included a "**Catalogue of all Dyeing Materials"** (ibid, 295)

Black: "*The three peculiar Ingredients for Black are Copperas, filings of Steel, and Slippe*" ibid, 295). Iron or steel was used "*in all true Blacks (called Spanish Blacks), though not in Flanders Blacks*" (ibid, 287). Slippe "*is the stuff found in the Troughs of Grind-stones whereon Edge-tools have been ground*".

Binding materials: "*The Restringent binding Materials are Alder, Bark, Pomegranate Pills, Wallnut rinds and roots, Oaken Sapling Bark, and Saw-dust of the same; Crab-tree Bark, Galls and Sumach* ".
. **Salts**: "*The Salts are Allum, Argol, Salt-peter, Sal Ammoniack, Pot-ashes, and Stone-lime*", and "*Urine as a liquid Salt*". This was "*Urine of labouring men, kept till it be stale and stinking*". The saltpetre and argol served "*to brighten colours by back boyling them*" (ibid, 291). "*Limestone is much used in the working of Blew-fats, being of Limestone calcined and called Calke".*

Liquids: "*The Liquors are Well-water, River-water, Wine, Aqua-fortis, Vinegar, juyce of Lemmon, and Aqua-fortis.: There is Honey used, and Molasses*". "*Honey, Yolks of Eggs, and Ox-gall*…[were used] *rarely; and as the conceits of particular Work-men, and for collateral uses (as to increase weight, promote fermentation, and to scour &c.)"* (ibid, 290). Well water, from below towns, was "a harsh water, wherewith one can scarse wash ones hands". It was unsuitable for dyeing blue, yellow or green, and was used mainly for reds, and for dyeing "*Callico, Fustian, and the several species of Cotton-works*" (ibid, 291).

Most dyers used river-water, which was "*sweeter; bears Soap; that is Soap dissolves more easily in it".* It "*must be had in great quantities for washing and rinsing their cloathes after Dying. Water is called by Dyers White Liquor"* (ibid, 293). *"Bran-liquors are used to* [with] *mealy dying Stuffs, such as Mather is, being the Powder or fecula of a root".* Bran liquor was "*one part of Bran and five of River-water, boyled together an hour, and put into leaden Cisterns to settle"* (ibid, 293). It had to be used within four days, and "*I conceive it contributes something to the holding of the colour".*

Adjunct materials: "*Ingredients of another Classis are Bran, Wheaten-flour, Yolks of Eggs, Leaven, Cummin-feed, Fenugeek-feed,* Agarick [toadstools?] *and Senna" (*ibid, 295). No information was given to Petty regarding the uses of the last seven materials. For dyeing silk, "*Gums are Gum Arabick, dragant, Mastick, and Sanguis Draconis".*

Cleaning agents: "*The Smecticks or Abstersives are Fullers-earth, Soap, Linseed-oyl, and Ox-gall"* (ibid, 295). Soap was "*pernicious in some cases, where Pot-ashes will stain or alter the colour*" (ibid, 304).

Minerals: "*The other Metals and Minerals are Pewter, Verdegrease, Antinomy, Litharge and Arsenick".* They "*use Pewter for Bow-dye Scarlet, viz. they dissolve Bars of Pewter in the Aqua fortis [nitric acid] they use; and make also their Dying-kettles or Furnaces of this metal*" (ibid, 287). "*Verdegrease is used by Linnen Dyers in their Yellow and Greenish colours".* Arsenic was used in Crimson dyeing. Petty thought the litharge (red *calyx of lead,* lead monoxide), antimony, and steel filings (slipp) used during dyeing had no role except to increase the weight of silk and other fabrics.

Colour Dyes: "*The Cobrantia colorata* [colouring dyes] *are of three sorts, viz. Blew, Yellow and Red*…[and] *Logwood, old Fustick , and Mather are the Pollyebresta [most popular dyes] in the present & common practices*" (ibid, 195).

*The **Blews** are Woad, Indigo, and Logwood: The **Yellows** are Weld, Wood-wax, and old Fustick, as also Turmerick* [which is] *now seldom used: The **Reds** are Redwood, Brazel, Mather, Cochineel, Safflowrs, Kermes-berries* [an insect], *and Sanders*." Sanders was "*seldom used, and Kermes not often. Unto these Arnotto and young Fustick, making Orange colours, may be added, as often used in these times*".

Copperas: "*Copperas is the common thing us'd to dye Blacks withal, and it is the salt of the Pyrites stone, wherewith old Iron (having been dissolved in it) is incorporated*". Petty decided that the block colour must be due to the iron present, since other materials were also blackened by contact with iron*: "green Oaken-boards by affriction of a Saw become black*", an apple cut with a knife became black, and the white grease put into iron-boxes on the axles of coach wheels turned black. "*And the black colour upon Earthen Ware is made with scalings of Iron vitrified".* Petty was puzzled that "*Allum seems to be of the same nature with Vitriol"*, but could not be used to make a black colour. "*Note, That where-ever Copperas is used, either Galls, Sumach, Oak Sapling-barks, or green Oak saw-dust, must be used with it."*

Red Colours: "***Red-wood** must be chopt into small pieces, then ground in a Mill between two heavy stones, as corn is. It is used also in Dying of Cloths and Rugs, and those of the Courser sort: The colour is extracted with much and long boyling, and that with Galls. The Colour makes a kind of Brick-colour Red; it holdeth* [the colour] *much better than Brasil"*. Only cloth which could withstand prolonged boiling could be coloured this way.

Brasil was chopped and ground the same way. "*It dyeth a Pink-colour or Carnation, imitating the colour of Cochineil the nearest: It is used with Allum for the ordinary colour it dyeth; and with addition of Pot-ashes when it is used for Purples."* Brazil steeped in water gave the "*colour of Claret wine*", while the addition of a few drops of vinegar or lemon juice gave the "*colour of Canary-sack*". A drop of "*Spirit of Vitriol*", sulphuric acid, gave *"a purplish violet colour".*

"Mather is a Root cultivated much in Flanders". When used skilfully with bran-liquor instead of water, it gave "*Cloth a colour the nearest to our Bow dye, or the new Scarlet*". Silk dyed with safflower gave a similar colour. "*This colour endures much boyling, and is used both with Allum and Argol; it holdeth well."*

*"**Cochineal** is of several sorts, viz. Silvester and Mestequa: This also is used with Bran-liquor in Pewter-Furnaces, and with Aqua-fortis "*, nitric acid.to give scarlet dye. Cochineal was a very concentrated dye, and a much smaller quantity was required than with other dyes to achieve the colouring. "*Colours dyed with it are said to be dyed in Grain". "Rags dyed in the dregs of the colour is* [are] *called Turnsole, and 'tis used to colour Wines; Cochineal being counted so far from an unwholesome thing, that it is esteemed a cordial" (ibid, 298).*

"Any acid Liquor takes off the intense Redness of this [Cochineal] *colour, turning it towards an Orange, Flame or Scarlet colour". "With this* [Cochineal] *colour also the Spanish Leather and Flocks are dyed which Ladies use. The extract or fecula hereof makes the finest Lake", or reddish colour.*

Arnotto dyestuff gave an orange colour, and "*is used with Pot-ashes upon Silk, Linnen, and Cottons, but not upon* [wool] *Cloth, as being not apt to penetrate into a thick substance*" (ibid, 299)

Weld (or Luteola) when in flower, was used with pot-ashes to give "*a deep Lemon colour, like unto Ranunculus* [buttercups]*, or Broom flower".* By reducing the quantity uses, it gave "*all Colours between White and Yellow". "This weed is much cultivated in Kent, for the use of the London Dyers; it holdeth* [remained anchanged] *sufficiently well but* [except on contact] *against Urine and Tartarouus liquors. Painters Pink* [for art] *is made of it"* (ibid, 299).

Wood wax or Genista Tinctoria, "called Grasing weed by the Dyers", produced similar colours to Weld, but was used in larger quantities. It was thought unsuitable for silk, linen or cotton, and mainly used for coarse wool cloths. It was applied in solution with pot-ashes or urine.

Siggefustick was a yellow dye made with Fustick wood, chopped, dried and ground up. Old Fustic was the tropical American tree Chlorophora tinctoria. Young Fustic was the European tree called Venetian sumac, Cotinus coggyria (Allen, 1991, 479)

Wood soot was believed to contain "*both a Colour and a Salt*", so it could be used directly, alone, to five "*the Colour of Honey; but it is the foundation of many other Colours upon Wool and Cloth*" (ibid, 300).

Woad "*is made of a Weed, sown upon strong, new-broken Land*…[It was] *cut several times by the top leaves, then ground, or rather chopt with a peculiar Mill*…[and] *made up in balls and dried in the Sun"* (ibid, 300). Later the balls were broken open and the woad gathered in heaps to ferment. About three days into the fermentation, "*it will come to work like a Kive of Beer, and will have a blew or rather greenish froth or flowry upon it".* It was sprinkled with water if fermentation was too fast, and with lime (or a stronger type of lime called Calke) and urine if fermentation was too fast (followed by bran if too much lime had been applied). "*English Woad is counted the strongest*" (ibid, 300). The best colour was "*a French-green*", and colour was tested using white paper, or a while-limed wall.

The importance of woad seems to have made dyers very reluctant to give full or accurate details to Petty. During dyeing they used pot-ash called 'ware', and 'hard-ware' if it had been "*double refin'd*", or alternatively calcined kelp seaweed, "*burnt into the hardness of a stone*" (ibid, 300). "*The making and using of Woad, is one of the most mysterious, nice* [skilful], *and hazardous operations in Dying. It is one of the most lasting Colours that is Dyed: An intense Woad-Colour is almost black, that is to say, a Damson-colour; this colour is the foundation of so many others in* [according to*] its degree* [of darkness], *that the Dyers have a certain Scale, or number of Stalls, whereby to compute the lightness and deepness of this colour*".

"***Indico** is made of a weed*…[but not the whole plant] *only a mealy concrete juice or fecula dryed in the Sun, sometimes made up into flat Cakes, sometimes into round-balls".*

*"**Logwood** is chopt and ground* [up] *like other of the Woods*…[and] *maketh a Purplish-blew; [it] may be used without Allum: It hath been esteemed a most false and fading Colour; but now* [that it is] *being used with Galls, it is far less complained of."*

Green : Petty seemed surprised, "That although Green is the most frequent and common of natural Colours, yet there is no simple ingredient, which is now used alone, to Dye Green with upon any Material; **Sap green** (being the densated juyce of the Rhamnons Berry) being the nearest; the which is used by Country people" 9ibid, 303).

Alum: *"Of Mineral-Salts used in Dyeing; the chief is Allum, the very true use thereof seems to me obscure enough, notwithstanding all the Narrations I could get from Dyers about it*"(ibid, 287). It is unclear whether Petty thought the Dyers had deliberately misinformed him about the use they made of alum, but he certainly decided they claimed to use it in several operations where it seemed entirely unnecessary.

"For I doubt

1. Whether it be [genuinely] *used to make Common-water a fit Menstruum* [solvent], *Wherewith to extract the Tingent [colour] particles of several hard Materials; for I find Allum to be used with such Materials as spend* [dissolve] *easy enough, as Brasill, Logwood, &c. And withal* [I also doubt the claim], *that the Stuffs to be dyed are first boiled in the Allum-liquors, and the Allum afterwards (as they say) cleared from the said Stuff again, before any Colour at all be applied.*

2. *Whether it* [alum] *be used to scour the sordes* [sticky dirt], *which may interpose between the colorander* [colouring matter] *and the Dying Stuff* [textile]*; and so hinder the due adhesion of the one to the other: the boiling of several things first in Allum seeming to tend {indicate action] in this way. But I find this work* [of cleaning] *to be done in Cloth and Rugs, by a due scouring of the same in the Fulling-mills with [Fullers} Earth, and in Silk with Soaps, by which they boyl out the Gums and other sords,* [that could result in the] *hindring or vitiating the intended colours.*

3. *Whether Allum doth internate* [penetrate into] *the hairs of Wool, and Hair-stuff, as Grograins, &c. , whereby they may the better, receive and imbibe their Colours ? Unto which opinion* [of their techniques] *I was led by the Dyers; saying, that after their Stuffs were well boyled in Allum, that they then cleared them of the Allum again: But we find the most open Bodied-Cotton and Silks, to have Allum used upon them; as well as the harder Hairs. Nor is Allum used in many Colours, viz. In no Woad or Indico Blews* [was any alum used]; *and yet the Stuffs Dyed Blew, are without any previous inteneration* [penetration by alum to open the hairs, yet] *quickly tinged* [accepted colour]*; and that* [occurred] *with a slight and short immersion into the Blew vat.*

4. *Whether it* [alum] *contribute to the Colour itself, as* [in the way that] *Copperas doth to galls, in order to make a black; or as juice of Lemmons doth to Cocheneel in the Incarnadives; or as Aqua-fortis* [nitric acid]

impregnated with Pewter, doth in the Bow-Scarlet, changing it from a Rose-Crimson to flame Colour. This use is certainly not to be denyed to Allum in some cases; but we see in other cases, that the same Colours may be Dyed without Allum, as well as with it, though neither so bright and lively, nor so lasting.

5. *Wherefore Fifthly, I conclude (as the most probable opnion) that the [genuine] use of Allum is to be a Vinculum [adhesive] between the Cloth and the Colour, as clammy-oyls and Gum-waters are in painting and Limming".*

Petty concluded his account of alum with his personal views on the various ways in which alum worked in the dyeing industry.

Alum as a Mordant: "*Allum being such a thing , whose particles and Aculei dissolved with hot Liquors will* [then] *stick to the Stuffs* [textiles], *and pitch themselves into the pores; and such also as* [will serve as places] *on which the particles of the Dying Drugs will also catch hold*, [exactly] *as we see the particles of Copperas and other Crystallizing materials, do of* [attaching on wood] *Boughs and Twigs* [placed] *in the Vessel, where such Crystallization is made"(ibid, 290).*

Alum as Dessicant: "*A second* [genuine] *use I imagine of Allum in Dying, to be the extracting or drying up of some such particles, as could not consist* [co-exist] *with the Colour to be superinduced, for we see Allum is used in the dressing of Alutas or white Leather, the which it dryeth*, [just] *as the salt of Hen-dung doth in Ox-hides, and as common Salt doth in preservation of Flesh-meat "* for food. *"We know a Sheep-skin newly flayed could not be Colour'd as Brasils are, unless it were first dressed into Leather with Allum; &c., which is necessary to the Colour even though the Allum be, as it is, cleared out of the Leather again, before the said Colouration, with* [the use of] *Bran, yolk of Eggs, &c"* (ibid, 290).

Alum to brighten colours: "*Allum, as it were by accident, makes a wet raw skin* [leather] *to take a bright colour: For as we see the first and most Glassie materials to* [do] *make the most orient colours, as Feathers, Flowers, &c. So certainly if by boyling Cloth in Allum, it* [thereby] *becomes incrusted with particles, as it were of* [resembling] *Glass, the tinging* [colouring] *of them yields more brightness, than the tinging of a Scabrous matter (such as unallumed Cloth is)"* (ibid, 290).

(51 A) Leather Trades – processing with alum

Leather was used for clothing, bottles and jugs, and luggage (Derry and Williams, 1970, 100).

Leather workers were particularly concentrated in pastoral areas of the east Midlands, particularly at Northampton and Leicester. Leather treatment was largely an urban industry in the Middle Ages**.** The tanning and leather-dressing trades were concentrated in large towns, notably London (at Bermondsey and Southwark) close to the meat markets and slaughter houses (Musson, 1981, 50). They supplied leather to independent craftsmen, the shoemakers, cobblers, cordwainers, glovers, purse-makers and saddlers. Cordwainers made quality shoes (resembling modern slippers) from cordovan, a Spanish leather, unlike the normal footwear of oxhide (Derry and Williams, 1970, 100). Shoes did not have raised heels until 1600, and tall boots were rarely made until later. Guild organisation was strong among these trades. Urban guilds strictly demarcated the tasks different artisans could perform. Butchers, who slaughtered and cut up animals, were not permitted to be tanners. Tanners could not be curriers.

The leather trade was organized in two quite separate sectors, making two types of leather. The skins of different species of animals were processed in quite different ways, by different craftsmen.

(1) The **hides of cattle** were sold to **Tanners** who processed them using oak bark (Statutes, 1763, 2, 415).

Tanning of cattle hides involved initial soaking in lime solution, then scraping with a knife to remove hair and fat, followed by a period of 'bating' in a solution made to bird and dog excrement in water (Musson, 1981, 50). The hide was then soaked for a long time in tan-pits containing oak-bark and water. Finally the heavy hides were curried using whale oil (called 'train oil') and tallow (animal fat).

Oak bark was collected in April and June. At a bark mill it was ground up in a large mortar or stone-lined pit, probably by horse powered equipment (SocDUK, 1833, 178). Ironworks, which made charcoal for fuel, sold the oak bark to local tanners (Clarkson, 2015). The Weald of Kent and Sussex had thriving ironworks and tanneries. Ironworks in the Forest of Dean sent oak bark to tanners in Bristol and Gloucester. Ironworks in Shropshire and the Walsall-Wolverhampton area of the Midlands supplied bark for tanning the leather used as saddles and harnesses.

The heavy, rough, dried leather was sold to Curriers, who used a shaving knife to reduce it to the correct thickness. It was washed, flattened and stretched, and then softened and made flexible using a dubbin of tallow and fish oils.

So-called Russia leather was dyed black by mordanting with alum and copperas and then treating with a solution of logwood (David, 1897, 580).

A general Statute of 1548 (Cap. XI) regulated the activities of tanners (Statutes, 1763, 2, 415). "*No tanner shall put any tanned Leather to Sale (saving* [except] *Calves Skins) tanned and mixed with Ashen Bark, Tapworth, Mear or Culver* [Pigeon?] *Dung, and unless it hath lien in the Tan-ozes* [oozes] *sufficiently wrought* [adequately strong] *three Quarters of the Year at least: Nor shall* [they] *overburn with Lime any Hides, nor shall set his Fats in Tan-hills, or shall put any hot Liquor or Ozes in the Fats wherein Hides shall be put to tanning: Or shall practice any other Way for* [causing] *the over speedy Tanning of Hides, or whereby they shall be burned or scalled* [scalded]; *Or shall cut any Hide of Steer or Cow to make Clout*[clothing]-*Leather thereof; Or shall tan any Sheep Shins* [Skins} *: Upon Pain to forfeit the same Leather, &c., and vj. s.*[shillings] *viij.d.* [pence] *for every Hide. EXP. 1 Mar. Sess. 2. C.15. Revived 1. El. C.9 and repealed by 5 El. C. 8. and 1 Jac. C.11."*

(2) All **non-cattle hides,** such as those of sheep and lambs, were sold to **Tawyers** or **Whittawyers.**

They did not use oak-tanning. Instead, the skins were first cleaned and then trampled in a paste made of alum, egg-yolks, whale oil (called 'train oil') and flour (Blair & Ramsey, 1991, 299). This was a shorter, simpler process than tanning of cow-hide, and involved a lower capital outlay (Musson, 1981, 50). To 'taw' means to make leather without using tannin. These leathers were used by the 'light' leather crafts (Clarkson, 2015)

This leather was softened by pulling it over a blunt blade, or by pushing a circular blade over the skin while it was held clamped in a wooden framework.

Northampton had both leather tanning and leather-dressing industries. There, in the 15th century, tanners were forbidden to process the skins of sheep, goats, deer, horses or dogs. These were processed by Whittawyers (Blair & Ramsey, 1991, 299). Shoemakers were called cordwainers after the Spanish "cordovan leather" used in the fourteenth century for shoes, but a substitute was later made in England from goatskins (Beaumont, 1872, 138).

Glovers and leather-dressers were widespread in western England, in the sheep rearing areas. London merchants bought sheep leather and gloves from Chester, Bristol, Ross-on-Wye and Brecon (Clarkson, 2015). Chester leather workers imported large quantities of sheepskins from Ireland.

Tanners, glovers and other leather workers were all present on the Isle of Wight, and in February 1698 petitioned the House of Commons complaining of the hardships caused by the tax on leather (JHC 1698).

Luke Hebert in 1836 showed that the traditional division of leather trades persisted: "*the preparing and dressing of lambs, sheep, deer, goat and other thin hides.. usually forms a distinct branch of the business*" (Hebert, 1836, 66). These supplied "*the immense demand of white and dyed leather, the (so called) Spanish and Morocco leather, of different colours and qualities…Of these, the white leather alone is not tanned, but is prepared by the process called <u>tawing;</u> but the coloured leather receives always a tanning, which is usually effected by sumach"*.

Good quality '**Morocco leather'** was made from deer and goat skins. Imitation 'Morocco leather', of lower quality, was made from sheep skins, and "most extensively used for book-binding, shoes, coverings to desks, furniture, and an infinite variety of other purposes" (Hebert, 1836, 68).

At Bermondsey, London, **lamb skins** were first soaked for some time in water, then remaining flesh was scraped off, before they were hung up "in a small close room heated by flues, where they remain to putrify for a given time", loosening the wool. The wool was then removed (and later sold), the skins scraped again, and then put into a pit of lime water to stop the putrifaction and remove slime. Skins were then transferred into a vat of bran and water, and left for some weeks "*in a state of gentle fermentation*", leaving "*a thin extensible white membrane, called a* ***pelt****, which is a condition that adapts it to any subsequent operation, of tawying, or dyeing, oil-dressing, or shammoying"* (Hebert, 1836, 67). Goat and kid skins were processed in the same way, except that the soaking in lime and water was done before removing the hair, since this was "*only employed by palsterers"* .

Pelts to be **tawed** were put into a warm water solution containing 3 lb. alum and 4 lb. common salt "*to every 120 medium sized skins, and worked therein till they have absorbed a sufficient quantity. This again gives the skins a remarkable thickness and toughness*". They were then washed in water, before entering "*a vat of bran and water; and allowed to ferment for a time, till much of the alum and salt is got out*". Then came a stretching on hooks, and drying in a room heated by a stove. Later they were washed again, then put into a tub of egg-yolks and "*trodden for a long time*", before being dried, and finished by "*glossing with a warm iron"* (Hebert, 1836, 67).

To make '**Morocco' leather**, the fermentation stage in bran and water was replaced by "*a bath of dogs' or pigeons' dung diffused in water"*. The skins were then sewn into bags, to expose only the outer side as they were immersed in vats of dye. Leather with "*the cochineal and Brazil reds are usually passed through a weak bath of saffron, which heightens the brilliancy"*. After dyeing they were put into a warm bath of sumach for some hours, "*until they are sufficiently tanned. Those skins that are intended to be black, are first tanned in sumach, without any previous dyeing, as the sumach (or the gallic acid contained in it) acts as a mordant, to strike a black colour by the addition of a solution of iron, which is rubbed over them by a workman with a stiff brush"* (Hebert, 1836, 68).

(52 A) German Technological Expertise – The Company of Mines Royal

The establishment of the Company of Mines Royal had a significant impact on investments in the later alum industry.

The **English partners** who were foistered onto what began as a German enterprise included aristocrats like the Earl of Leicester and later Baron Mountjoy, alongside both wealthy merchants like Duckett and speculative merchants like De Vos.

For those who later invested also in the alum industry, it provided both social contacts and opportunities for raising loans. Robert Cecil was a member, and central government took a close interest in developments at Keswick. The commercial experience gained by English participants probably helped to shape attitudes towards many other mineral enterprises.

In **1561** a German mining engineer, **Johann Steynberg**,, with help from **Thomas Thurland**, Master of the Hospital of the Savoy in London, Thomas Thurland, with the government for the right to open mines in the Lake District (Jenkins, 1937, 225). He returned to Germany to seek financial support from the **Augsberg merchants David Haug, Hans Langnauer &** Co., who were already financing mining and smelting in the Tyrol and in Hungary.

They sent **Daniel Hoechstetter (1525-1581),** a native of Augsberg, to act as their agent in England. Daniel was probably a member of the Hoechstetter family that earlier had close links with the London Merchant Adventurer partners Sir Richard Gresham (c.1485-1549) (DNB 2004, 23, 761) and William Copeland. They exported English cloth and imported velvets, satin and tapestries, and had close links with the Hoechstetter house at Augsberg for their Baltic trade.

The Hoerchstetters had invested heavily in mining in Germany, but went bankrupt during a mining crisis in 1528 while over-extended trying to establish a world monopoly in mercury. Daniel's father Joachim had operated a gold mine in Scotland in 1526-9 (Ash, 2004, 46).

On 8th July **1563 Elizabeth I granted a licence** to prospect for minerals to Daniel Hoechstetter (DNB, 2004, 27, 519) Eventually in October 1564 a patent was granted to Thurland and Hoechstetter, giving a six year monopoly to dig for gold, silver, copper and quicksilver (mercury) in the northern and western counties of England and Wales. The Crown would receive ten percent of any precious metals found.

Daniel Hoechstetter had learned techniques for mining and refining lead, copper ,and silver, in the Tyrol (DNB, 2004, 27, 519). He quickly chose a good mineral prospect near Keswick in Cumberland, and returned in 1564 with a relative, **Hans Loner**, and twelve German workmen.

In 1565 between forty and fifty **Germans arrived from Gastein** in the Tyrol (Bourch, 1961, 120). More came, from Styria, in 1566-7. They were **Lutherans**, and were at first were welcomed by local residents.

By 1568 ore was worked at Newlands, Borrowdale, Calderbeck, Grasmere and Buttermere. It was broken manually with sledgehammers, then crushed in a stamp-house under heavy iron-shod timbers raised by a waterwheel. Smelting and refining was done at Brigham (Brigholm) near Keswick.

Thurland was short of money and could not match the capital investments from Augsberg,. He petitioned the government for permission to **form a company and sell shares** to Pembroke, Leicester, Cecil and Duckett (Price, 1907, 49). The Germans had originally wanted to finance and operate the mines independently, and disliked the new arrangement (Ash, 2004, 51).

In **1568 the Society of Mines Royal** was established as a joint stock company under letters patent. Original members included William Cecil, William Herbert (first Earl of Pembroke), Robert Dudley (first Earl of Leicester), Lionel Duckett, 'Customer' Thomas Smythe (d.1591) (qv), and the Augsburg partnership of Haug,, Langnauer and Company. Known as the Mines Royal, it soon exposed weaknesses in the English commecial environment.

In 1564 under preliminary arrangements, the Augsberg partners held eleven shares, Cecil and Leicester only had two each, while Thomas Thurland held between two and a half and one and a half at different tines (Bouch, 1961, 122). **Cornelius De Vos** had one share from 1564 to 1566, and a quarter of one share in 1567. Alderman Lionell Duckett, with one share, may have been related to Jeffrey Duckett (with one quarter share) and local man Anthony Duckett of Grayrigg. Shareholder John Dudley also had a local relative, his brother Richard at Yarnwath (Bourch, 1961, 122).

In **1566 Hoeschstetter** designed the **refinery built at Tintern** to process calamine ore, recently found in the Mendips. He was employed by the partnership of **William Humphrey** of the Royal Mint, and Christopher Schultz, which later became the **Company of Mineral and Battery Works**. They concentrated on making wire, rather than hammered (battered) goods.

The English partners in Mines Royal distrusted the Germans, and local Keswick residents became openly hostile. Despite official Crown protection for the miners, Leonard Stoultz was murdered during civil disturbances in 1566 (Ash, 2004, 42).

The Keswick mines produced a lot of copper, but little silver. Exports of copper were banned because it could be used to make brass ordnance. The domestic market for copper was very restricted, even though the Mineral and Battery Company waived its monopoly over the making of shaped-copper goods.

No Englishman had the skills to monitor the activities of the Germans. **William Humfrey** tried and failed to independently assess the value of the Keswick ores. During 1566 he then asked Cecil to request the London merchant Thomas Gresham, who traded in Antwerp, to recruit a Flemish mineralogist or goldsmith, fluent in German, to work in Keswick as a spy (Ash, 2004, 44). This was not done.

At Keswick the English partners in Mines Royal appointed **Thomas Thurland** as their trusted representative to keep an eye on the activities and expenditures of the German miners (Ash, 2004, 5). Thurland realized that he lacked adequate technical knowledge to be effective.

Thurland became alarmed in **October 1566** when **Cornelius De Vos arrived in Keswick** with two unnamed companions, one English and one Scottish. This was shortly after the death of the mining expert Leonard Stoultz, while Daniel Hoechstetter was absent in Augsberg. De Vos had come from Crawford Moor in Scotland, on the River Clyde. Daniel's father Joachim had prospected for gold there in 1526 (Ash, 2004, 46). De Vos refused to explain his presence to Thurland, and privately consulted with the German miners.

Thurland stole a knapkin from De Vos, which contained some of the sand he had brought from Crawford Moor to show to the Germans. He wrote to Cecil on 7th October 1566, reporting the visit by De Vos and enclosing a second letter to go directly to Queen Elizabeth (Ash, 2004, 46).

De Vos apparently lacked the expertise to evaluate the mineral prospects at Crawford Moor. He had brought samples of sand which previous prospectors on Crawford Moor had washed and discarded (Ash, 2004, 46). The Germans at Keswick assayed it and claimed it was rich in gold. In return, De Vos told them he could supply them with sand worth 10,000 marks by Christmas, if they would process it. They seem to have deliberately misled De Vos. Certainly no agreement was made, and the Germans later volunteered details to Thurland details of their meetings with De Vos.

Thurland persuaded the Germans to make an assay in his presence of the sand stolen from De Vos. Again they found it rich in gold, but said they thought De Vos had deliberately salted it with gold from elsewhere.

Thurland suggested to William Cecil that a German miner should be employed to travel secretly to Crawford Moor and report directly on the prospects there, or that Queen Elizabeth could negotiate directly with Mary Queen of Scots (1542-1587) to grant the Company of Mines Royal a monopoly over Crawford Moor ((Ash, 2004, 47).

Instead, the Scots gave a **19 years monopoly** of prospecting rights over **Crawford Moor to De Vos**. De Vos then sold his share in the Mines Royal and established his mining company in Scotland in 1568 (Ash, 2004, 48).

The possibility remains open that other members of Mines Royal also participated in that venture. In October **1568 Mr Rennier**, a Dutchman apparently representing the **Scots company**, arrived at Keswick. He requested Hoechstetter to assay more samples, and to send skilled workmen to Scotland. No one seem to have gone. The requests were reported to the English manager, **George Needham**, who dutifully informed Lionel Duckett in London (Ash, 20904, 48).

The Cumberland mines continued to operate successfully, but made little or no profit. Thurland himself distrusted the Germans. **Lionel Duckett** ensured all accounts books were translated into English from 1568 (Ash, 2004, 51). The **English partners refused to invest more** for equipment to manufacture finished goods of copper. William Humfrey actually advised Cecil against taking advice from **John Chaloner, of Lambay** in Ireland, who was known to be an advocate of the advanced German technology described by Georgius Agricola (Ash, 2004, 53).

By 1569 the Company was **mining lead** as well as copper. Lead was used to extract silver from the copper ores, and was itself an additional source of silver. By 1572 additional lead was being brought from Teesdale, Allendale, and Richmond in Yorkshire (Bridge, 1999).

German shareholders became increasingly frustrated by the continual accusations of deception by English partners, who took no active managerial interest. In 1572 they stopped investing in new equipment (Ash, 2004, 51). Nevertheless, by 1574 silver was being sent regularly to Richard Martin at The Mint in London (Bridge, 1999). During 1574, coppersmiths arrived in Keswick and built a water-powered hammer.

Shareholders were very critical of the management by Daniel Hoechstetter, and in 1579 brought in two independent experts. **Hugh Brinckhurste junior** from Erffurt and Phillip Bayer of Strassburg assayed the copper ores. They claimed two thirds of the copper was not being recovred.

Haug, Langnauer and Company withdrew from the Mines Royal in 1579. Hoechstetter agreed to run the operations at his own expense only after the Mines Royal allowed a lease of the mines at a fixed rent (Bridge 1994). The Company of Mines Royal only survived because '**Customer' Thomas Smythe** (Smith) persuaded some of the original English partners to provide that lease (Ash, 2004, 51). Smythe was one of the wealthiest London merchants.

By careful cost-cutting the business became profitable. When Hoechstetter died in 1581, one of the few active shareholders, **George Needham**, employed chemist and metallurgist **Joachim Gaunse** to analyse the ores. Gaunse recommended major improvements to the smelting methods, giving a large saving on fuel, and also suggested the sale of by-products especially copperas (ferrous sulphate) and blue vitiol (copper sulphate) (Bridge, 1994). Two sons of Daniel Hoechstetter (d.1581), Daniel and Emmanuel, continued to operate the Keswick mines until 1634 when they went bankrupt.

About a hundred of the original German miners spent the rest of their lives in England. Sixteen had taken English wives by 1567, and sixty by 1600. De Vos many not have been the only mineral prospector from elsewhere in Britain to visit Keswick for advice from the Germans.

(53 A) The Cornelius De Vos Charity – Eastcheap, London 1556

Cornelius De Vos purchased property in **Pudding Lane**, London, where he seems to have lived during the 1550s with his wife Helen. The earliest records are missing, probably due to the Great Fire, which started at 1 am on 2nd September 1666 at Thomas Farriner's bakery, nearby on Pudding Lane.

Later records suggest that before leaving London, De Vos had made legal arrangements for the property to be used by his wife during her lifetime, and thereafter to fund a local charity. Like other information about De Vos, there is great confusion about what actually occurred.

After Cornelius left, Helen seems to have remarried to John Gylmin (Gylmyn), and was known as Helen Gylmin. Deeds prepared in 1556, possibly at the time of her remarriage, placed the property in the hands of trustees so that the couple could continue using it. Gylmyn is an unusual surname. A '**gymlyn'** was an instrument for tapping a barrel.

The date 1556 is surprising since De Vos was probably still living in England, in Dorset. He continued to do so until about 1565.

Helen probably survived **John Gylmin**. She may have married a third time, taking the surname Howe. Alternatively, the name Howe was a later error in the records. After her death the property passed to Christ's Hospital, which administered the charity.

Christ's Hospital was founded in 1552 by Edward VI as a school for the orphan children of poor Londoners (Manzione, 1995). It received a charter in 1553, and was housed in the buildings of the former Grey Friars Monastery in Newgate (CH 2015). The children left at age 15 and were expected to work in trade or commerce.

The charity persisted, and surviving written details were collected in 1829 when Commissioners investigated endowed charities in London (ECL 1829), and in 1837 when a similar Commission reviewed charities of England and Wales (RCC 1840).

The charity Commissioners first report on the **parish of St. Leonard, Eastcheap**, stated: "*Helen Howe's Gift – In 1604 Mrs Helen Howe, by deed, directed that the sum of 4 l. annually should be paid out of the rent of a house in Pudding-lane, to be distributed in the winter, for the relief of the poor residing in Billingsgate Ward, in coal and faggots [wood], as they should be wanted. This sum of 4 l. is received yearly from Christ's Hospital, by the churchwardens of St. Leonard, and is by them distributed among all the parishes of Billingsgate Ward"* (ECL, 1829, 82)

The Commissioners later reviewed the documentation held by Christ's Hospital (ECL, 1829, 327). In 1810 it possessed the property at No. 28 Pudding Lane under a deed dated 26 April 1556. The property was owned by John Gylmin and his wife Helen, and the deed transferred it into the hands of trustees, Rowland Hill and John Rose. It was to remain used by John and Helen, until her death, and then to pass to the governors of Christ's Hospital.

Christ's Hospital was to pay the rector and churchwardens £4 per year on All Saints Day, for the relief of the poor in the ward of Billingsgate. Hill and Rose directed that of that sum, £3 16s 8d was to be in the form of coal and shifts (textiles), and 3s 4d as cash to the churchwardens.

Later errors in the records of the Hospital recorded the deed as having been in 1604, from Mrs Helen Howe, and by mistranslation of Latin in the deed, "*carbonibus et camissis*", the gifts were to be as coals and fagots (presumably wood not food).

"*This information was derived from the entries in the hospital ledger, in which this charity has been handed down from a very early period as the gift of Cornelius Devose and Helen Howe, in the years 1569 and 1604,. It seems probable that the property came into the possession of the hospital in 1604, on the death of Helen, who might have acquired the name of Howe by an after-marriage* [following the death of John Gylmin].. *In what manner the name of C. Devose became connected with the benefaction does not appear; but there seems no doubt, that the charity originated in the deed of 1556*" (ECL, 1829, 327).

St. Leonard's parish held an account of local charities, compiled in 1772 by the churchwarden William Oliver: *"Lady Howe bequeathed to this parish three shifts, if made up, or cloth for three shifts, and 2s 2d in money, which is paid by the churchwarden of St. Leonard, Eastcheap, at Christmas. The above legacy is to be disposed to three poor women of this parish, not in the workhouse*" (ECL, 1829, 327).

The Charity Commission of 1837 re-examined the documentation and made another attempt to determine the original intentions of the De Vos charity.

They found that under the terms of the original trust, John Gymlyn was to receive 40 shillings per year if he lived longer than Helena. Ownership of the property was to pass to the Mayor and corporation of London after her death.

From the rent on the property to the value of £4, a payment of 3s. 4d. was made to the churchwardens of St. Leonard's parish. In return, four times a year on major feast days they were to distribute the remaining £3 16s. 8d. in the form of coal and shifts (of textile), to the poor in the ward of Billingsgate. The churchwardens were empowered to enforce their right if the Mayor and corporation refused to pay.

Helena, with the approval of her husband John Gylmyn, later changed the terms of the trust. Ownership after her death went to Christ's Hospital, not to the Mayor. She apparently omitted to include the charitable gift of £4 per year.

The Commissioners in 1839 concluded that in terms of the annual gift, "*the trusts of the prior grant have been regarded as those by which the said property is bound*". The ownership went to Christ's Hospital.

The 1839 report referred to "*her third husband **Cornelius De Vos***". This was either an unfortunate turn of phrase, or it shows that John Gylmyn was her fourth husband. The house in Pudding Lane where John and Helena lived was "*formerly in the tenure of **Nicholas Howe***". It is possible that Howe was Helena's second (or even fourth) husband, and that the house was purchased by De Vos who vested the ownership on Helena.

"GIFT OF HELENA GYLMYN, alias *DE VOS*, alias *HOWE*

By indenture of foeffment bearing date 26th April, 2 and 3 Philip and Mary, reciting that John Gylmyn *and* Helena *his wife had by two indentures, bearing date 20th and 21st April, then last, conveyed the messuages therein mentioned to Rowland Hill and John Rost, their heirs and assigns* (sic*), in trust to regrant the same to the said John Gymlyn and his wife Helena for the life of the said Helena, with remainder to the mayor, &c., to the intent that the said mayor, &c., might pay annually to the rector and churchwardens of the parish of St. Leonardsin Eastcheap 4 l. for the relief of the poor dwelling in the ward of Billingsgate, to be laid out and distributed annually in coals and shifts – it is witnessed that the said Rowland Hill and John Rost thereby granted the said premises by the description of a messuage, or tenement, in the parish of St. Margaret's in Bridge-street, to the said John Gylmyn ad Helen* (sic) *his wife, for the life of the said Helen* (sic), *with* *remainder to the use of the mayor, &c., for ever, paying yearly, after the death of the said Helen, 40 s*. (sic) *a year to the said John Gylmyn during his life, and paying yearly for ever to the said rector and churchwardens and their successors, 4 l. at the usual four feasts; and the said mayor, &c., covenanted that if such rent-charge should be in arrear 20 days, it should be lawful for the rector, &c., to enter and distrain upon the said premises; and the said rector, &c., for themselves and their successors, covenanted with the said mayor, &c., that they would yearly, within two months after receipt of the said rent charge, expend the same among the poor dwelling in Billingsgate ward, 3 l. 16 s. 8 d., in coal and shifts, and keeping the remaining 3 s. 4 d. for the churchwardens for their trouble.*

The same tenement appears to have been subsequently made the subject of a conveyance in the 15th Elizabeth, by the said Helena De Vos, under the erroneous supposition that her third husband, Cornelius de Vos was dead. Her grant, which was to the hospital, only omitting the rent charge to the parish of St. Leonards, Eastcheap, was confirmed by her husband in the 19th Elizabeth; but the trusts of the prior grant have been regarded as those by which the property in question was bound.

The house derived from this gift is No. 28 Pudding-lane, now let to Josiah Morrill, at 83 l. 10 s. per annum.

The rent charge of 4 l. per annum is regularly paid to the churchwardens of St. Leonard's, Eastcheap.

(54 A) Gerard de Malynes - Business Consultant and Mining Promoter

The Antwerp born **Gerard de Malynes** (c.1584-1641), a London merchant since 1585, became a business consultant, economist, mining promoter and publicist. His father was a mint-master who may have emigrated from England in about 1552 to Antwerp, before returning to England in 1561 when Flemish craftsmen were recruited to improve the quality of the English coinage.

Gerard claimed his ancestors were from Lancashire. He became a merchant engaged in foreign trading, an assay master of the Mint, and a government advisor on trade. He published a number of texts on economics.

He believed that a country's wealth was based on the accumulation of precious metals. He showed how an outflow of precious metals from a country could reduce domestic prices (with less money buying more goods), while raising the prices of foreign goods for import. He proposed higher import tariffs, and a prohibition of bullion exports.

Many of his views, and details of his mining interests, appear in his 1622 textbook ' *Consuedo, vel, Lex Mercatoria, or The antient law-merchant: divided into three parts according to the essential parts of traffique; necessaie for all states-men, judges, magistrates, temporall and civile lawyers, mint-men, merchants, mariners, and all others negotiating in all places of the world*'.

About 1586 he was appointed a commissioner of trade in the Low Countries. Back in England in 1587 he purchased from Sir Francis Drake some of the pearls from Cartegena. The Privy Council often sought his advice on commercial affaires. While an 'Act for the True Making of Woollen Cloth' (4. Jac. I c.2) (1606) was being debated, he reported to the Privy Council on the weight, length and breadth of all kinds of cloth.

Malynes had extensive business contacts and was very important in the early metal mining industry of north east England as well as in the origins of the Yorkshire alum industry. Usually he did not invest significant sums of his own money, but acted as a technical expert and go-between, connecting wealthy merchants with the representatives of the Crown and landed aristocracy best able to further their commercial ambitions.

His main mineral interest was in metals, especially precious metals. In 1598 (fourteen years before the 1622 book) he seems to have personally financed seventeen German miners to travel to north east England and assist in mineral prospecting.

With a partnership of commercial backers, he had been encouraged "*by a great person then in authority and now deceased, who promised all the favour that he could do*" (Malynes, 1622, 181). This was probably Robert Cecil. At the last minute that "*great person*" and another Lord (possibly Eure) withdrew their backing for the merchants, and "*the poor* [German] *men went begging homeward, to our exceeding great loss".*

Malynes stated in an undated letter of c. 1607/8 to the Lord Treasurer, Dorset, that two years earlier he had been consulted by a self-styled 'Alum Company' over the possibility of obtaining an alum monopoly (DNB, 2004, 36, 380). That Company had many partners, led by William Turner, William Angell, William Hawses and John Archer. Exactly how the 'Alum Company' already knew the alum potential of Yorkshire is an unanswered question. Malynes later wrote about Atherton's alum works of 1604 in his *Lex Mercatoria, or The Law Merchant* (1622) (Turton 1938, 64).

Malynes advised the Company to obtain influential supporters, because alum was not a new invention, and there would probably be opposition from Lord Eure and Lord Danvers who had alum interests. Eure may have had an interest in the Shropshire alum springs at Okengates, used by Shrewsbury dyers (Turton 1938, 71). Danvers held land in Cleveland. The Alum Company did find powerful supporters.

Malynes himself seems to have been the leading promoter of an earlier partnership, involving Lord Eure and several prominent London merchants, to work silver in County Durham, and lead and alum in Yorkshire (Bense, 2013, 125).

Under that scheme, mining experts from Germany had been employed, but the project collapsed, apparently by 1606 (DNB 2004, 36, 381). Details are lacking, but the very early date of that scheme makes the possible involvement of German experts in Yorkshire intriguing (Malynes, 1622, 262).

That failed venture by Eure and others may have dug the mines in Yorkshire which the alchemist William Smedley claimed to know about in the early 1570s while Society of New Art project was still based at Canford in Dorset.

In his 1622 volume '*Lex Mercatoria, or The antient law-merchant',* Malynes stated: *"…I call to memorie a conference, which in the yeare 1606 (being in Yorkshire about some Allome Mines, and certain lead mines in Richmondshire) passed betweene the Archbishop of Yorke Doctor Mathew, and my selfe, in presence of Ralph Lord Eure, with whom I went to Yorke to congratulate the said Archbishop newly come to See, which was concerning the Center of the earth, which he said was unknown…*" (Malynes, 1629, 184)

The date is likely to be correct, since Tobias Matthew (1546-1628), a former Vice Chancellor of Oxford University, did indeed become Archbishop of York in 1606. It is possible that Malynes had visited Slap Wathe, and that he was the originator of the 'Alum Company' rather than simply its adviser. Some of its members may even have been connected with the earlier lead mining project.

That failed venture by Eure and others may have dug the mines in Yorkshire which the alchemist William Medley claimed to know about in the early 1570s while Society of New Art project was still based at Canford in Dorset.

Ralph Eure (1558-1617) was the eldest son of William, the second Lord Eure, captain of Berwick castle, and Margaret nee Dymnocke (HPM Eure 2015). He was educated at Cambridge, and in law at Gray's Inn (1575). He pursued a career as an upstanding and loyal officer of the Crown, with no major commercial interests.

Lord Eure became a J.P. in Yorkshire West Riding, and later Sheriff (1593-4). He was a member of the Council in the North (1594-1614) and Warden of the Middle March (1595-8). To Cecil he called the Scottish Borders a place with no religion, no justice, no horses and no supplies. To combat the lawlessness he codified the penal laws, which angered those at Court who were profiting from the existing confusion.

Witton Castle on the River Wear at Witton Le Wear, 12 miles south west of Durham, was the ancestral home of the Eure family (Moule, 1837, 2, 320).

Malynes wrote extensively and his books show some errors. He wrongly believed that the 'West Indies' covered some inland localities in Central and northern South America which had important Spanish mines.

He thought that Santo Domingo (a mine in Chile) was an island in the West Indies (Baldwin, 1778, 10). He may have been deliberately misled by some foreign technical experts, since he did keep a form of daybook to record useful information. Some of the metallurgical techniques outlined were also misinformed.

His lengthy book '*Lex Mercatoria'*, first published in 1622, seems to have reached a wide audience. It was reissued in 1629, and the section on precious metals and coinage was copied in George Sawbridge's '*Universal Library'* of 1712 (Sawbridge, 1712, 1, 370-378).

He hoped to stimulate interest in finding metals in Britain, though knowledge of geological processes was poor. The best way to find gold was by searching along "Rivers of Water running about the hilly places… which the *Spaniards* did much regard in the *West Indies*, seeking after mines…" (Mayles, 1629, 182).

After *"… having found any vein of a Mine* [ore*], they will persue the same towards the East, and seek to find out (as it were) the trunk or body of the Tree*…[saying*] we must always seek after the body of the Mine* [ore*]; which may be sometimes three or four feet broad, when the veins are like an arm or a finger"* (Malynes, 1622, 184).

"*Chapter II Of Mines Royal*

The Mines [ore] *called Royal are only of Gold, Silver and Copper, of which three metals Princes have made choice to make their Monies… But foreasmuch as Silver is found in the Lead Mines*…[often] *Princes will claim their interest in some lead mines…"*

In a dispute between Elizabeth I and the Earl of Northumberland , it was decided (according to Plowden's ' Commentary of Book Cases') that if the value of the silver exceeded the value of the gold, after deducting refining costs, then it was a Mine Royal.

Malynes regarded the placer gold found in river alluvium to be the highest quality. It did not require refining and was "*Maiden Gold, so called because it was never in the Fire*". Gold suitable "…*to make Money is called Aurum obrison: Such was the gold which Sir Bevis Bulmer brought out of Scotland, found in the Sands of the Rivers near to the Gold Mines of Crayford* (sic) *Moore, which was above 22 Carrats fine…I saw some 18 Ounces of it which was in big Grains, some like peas* [once] *found out by Shepherds*". Those shepherds may have found the first gold there.

Vein gold was also present in Scotland, *"…within a white spar [quartz vein] wherein it growth, near the superfices* [surface] *of the Earth, and runs into small veins like pins, fit to be refined by Quick-silver [extraction using mercury] from the Spar"*. Malynes also claimed to have seen Spar-gold in an English place it could never have been, near Lincoln at Brickel-hill.

Malynes reviewed world sources of gold, including European supplies from Bohemia, Pannonia in Hungary, Sweden, and Spain, before claiming that a global shortage was developing. "In the Island of *Santo Domingo* all is exhausted also; and so it will be in *Perou,* and the *West Indies*". The Dutch had found no gold in the East Indies.

He claimed that silver was also in short supply. "*The silver mines of* Hungary *and* Bohemia*, as also* Sweden*, are drawn out, but do continue in* Germany *(in many places*".

Just as "…*all Lead Mines [ore] contain some Silver…Silver likewise containeth some Gold, found sometimes to be three or four Ounces in one hundred pound weight* [1600 ounces]*, besides the Copper in the Silver ore".*

Malynes wrongly stated that: "The Mines in the West-Indies are the principle [main source] in quantity of Poor Ore, where many hands make light work". The King of Spain was said to supply authorized contractors there with money and Quick-silver in return for a tax in silver.

Don Rodrigo de Cordna, reputedly from the West Indies, had told Malynes that the ore at Potosie (sic) mine "*containeth not above 1 ½ ounce of Silver in a hundred: The like was affirmed by a* Portugal [man] *called* Antonio Diaz*, who had dwelt two and thirty years in the said West Indies.*

I was Interpreter between our sovereign Lord James, and the said Antonio*, when he made the trial of the Silver Ore of Scotland in the Tower of* London *with quick-silver before the King, and did inform his Majesty hereof*".

Malynes claimed the mines of Germany were richer in silver than some of those he wrongly thought were in the West Indies. Besides *"…the Mines of the Earl of Mansfield, and others that are in Tirol* (sic) *and other places in Germany"* which made a profit, the Duke of Brunswicke operated silver mines at a loss to provide local employment and to make silver dollars.

"I cannot therefore without grief discourse of the Silver Mines of this Monarchy of Great Britain*, and heartily lament to see them lye dead, and buried in oblivion, because I have heretofore fought to advance the working of them:*

For it is now about 14 years since [1598] I caused divers workmen to come out of Saxony, Brunswicke*, and other places of* Germany*, at my great charges, to the number of seventeen persons, some for the Silver Mines in the Bishoprick of* Duresme *[*Durham]*, others for the Lead Mines in* Richmond-shire *in the county of* York*, some for the Allom works there also and some for the making of Steel in* Wales*, wherein the noble Lord* Eure *deceased, and certain London Merchants had undertaken to proceed with me.*

The action being applauded by a great person then in authority [Robert Cecil?]*, and now deceased, who promised all the favour that he could do; but he had some other privat designs herein, as he had also in the Silver Ore of* Scotland*, whereof we are now to intreat* [review]:

Insomuch that the actions of these two lords were like unto Phaeton's *horses, for all was fed into a combustion, and the poor men* [German miners?] *went begging homeward, to our exceeding great loss of the benefits in expectation, our Mines* [ores] *being richer than those of the* West-Indies*, whereof I have made and caused to be made many trials above twenty several sorts of Silver Ores.*

The two Silver Mines of Muggleswike *and* Wardal *in* Duresme *contain six and eight Ounces of Silver in the hundred, which being fallen in, may with a reasonable charge be brought in [to] working, according to the information which I took of the Inhabitants there, at which time I did intend to go further into* Lancashire *to* Slaithborne *Mine holding above four Ounces of Silver in the hundred:*

But being in the winter time, and the weather very foul, I was diverted, not without discontent, because it is the county where my Ancestors and Parents were born.

The Silver mine at Combmartin *in* Cornwal *holdeth ten Ounces in the hundred, where* Sir Bevis Bulmer *did work for a time, which is deep and overflown with water…"*

Malynes was correct about Muggleswick, in County Durham, which was later reopened for precious metals (durhamintime, 2015). But Wardel was a coal mine.

Scotland appeared to have promising silver prospects. In 1607 a coal miner ("*collier*") employed by Sir Thomas Hamilton, Advocate of Scotland, had discovered a small vein of silver ore within 18 miles of Edinburgh. Assayers could not agree on the proportion of silver present, which was between 20 and 80 parts per hundred.

The Crown organised a large scale random trial. During this, Malynes watched the "*tryal made by the* Portugal [refiner] *with Quick-silver, who found 23 or 24 Ounces"* (Malynes, 1622, 184)

"*In the month of August, 1608, there came two Ships before the Tower of London from Scotland, laden with some 400 Barrels of this Silver Ore, in weight some 100 Tuns lading which were there landed, and delivered unto the Lord Knivet, Warden of the Kings Mints, whereof 20 Tuns was taken promiscuously and grinded, and afterwards also distributed unto divers refiners and others*" (Malynes, 1622, 185).

Elsewhere Malynes states that the King and Privy Council arranged for "*ten Tuns of the said Silver Ore to be brought into the* Tower *of* London*, whereof one Tun of 2000 lbs. weight was indifferently taken and calcined or grinded together, and thereunto were two Tuns of Lead added, commixed, and afterwards Molten by a continual Fire and Hand-blast of four men according as [to what] I have noted in writing.*

And there was a cake of Silver remaining weighing 17 ½ Ounces, and the [further] extraction out of the Lead was some 4 or 5 Ounces more; so that it was reported to be 22 Ounces in the 100 weight of Ore, but the charge [expense] *was great".*

Other refiners also tested the ore. William Beale roasted it and used a lower proportion of lead for the extraction. Others mixed lead ore with the silver ore, to reduce the cost of using refined lead. They all claimed to recover 22 ounces of silver per 100 ounces of ore. Mr Broud achieved 28 ounces of silver.

Sir Richard Martin received three tons of the mixed ore for testing. He gave to Malynes "*…20 lbs. weight of the said Ore, grinded, shaddered and washed, which I did send beyond the seas unto an expert Mint-master*", who claimed to recover 42 ounces of silver from 100 ounces of ore.

He reported that the ore "*had little or no Lead; and that the commixture of the Mine was very brittle, and Bell-metal, and so did all the other refiners affirm. For the old Ore doth look between white and blue for the most part, and is like the Bell-metal found in good quantity about* Bristol, *which is used to make some kind of Alchymy beyond the seas, and this must be allaid to qualifie the brittleness with some Mineral, of all which I have made a Record in my Book of* [Re]*Collections ".*

Lack of consistency in the analysis of silver content produced scepticism over the value of the ore (Malynes, 1622, 185).

*"*Interim, *these trials and conclusions so differing, brought the said ore (together with other proceedings) into some disgrace, whereupon (according unto Commission given me) I made an offer to buy the 80 Tuns remaining in the Tower, to a great Personage, to give for it 24 pound the Tun, to be transported to my frient into* Holland *paying ready Money.*

Time was taken to give me answer, and then difficulty was made, for that treasure was not to be exported unless by returning the [equivalent*] quantity of Silver by weight; hereupon conclusion was made to bring in so much [*agreed quantity as compensaton, in*] Bullion of Silver, of Royals, of Plate.*

But when all came to all, with running up and down, and further offering to deal in far grater quantities, and to take it in Scotland, I was put off with this consideration, that it was a dishonour to England not to have men of as good experience as any [others] *were beyond the Seas, whereby the Kings loss was 2000 lbs, for his Highness gave the same* [ore] *afterwards unto* James Achinson *his Graver of the Mint heretofore, who brought the same to nothing, being unskilful of the refining of it. And thus are good matters marred in the handling, and Works brought to a stay or hindered".*

In 1609 Malynes sat on the Commission on Mint Affaires, with Thomas Knyvet (first Baron Knyvet), Sir Richard Martin, John Williams (the King's goldsmith), and others.

When Parliament debated 'An Act for the True Making of Woollen Cloth' (4 Jac. I, c. 2), Malynes investigated the weight, length and breadth of all types of cloth in England.

In 1612 he proposed to reform the national deficiency in low denomination currency, which had led many traders to strike farthing tokens in lead, infringing the royal prerogative on coinage. In April 1613 John Harringdon of Exton obtained a patent to make farthing coins.

Malynes and **William Cockayne** 'farmed' the patent, but Cockayne soon withdrew and was replaced by John Couchman. The farthings were widely disliked, and traders continued to produce their own tokens instead. Malynes was imprisoned in the Fleet for debt for a time in 1619 when those in debt to him would only repay in the unwanted farthing coins.

Gerard de Malynes' book '*Lex Mercatoria'* (1629), was written in 1622 as a compendium of commercial data, laws and techniques, both English and world-wide. It also showed merchants how to detect common frauds like defective cloth. The essays were very detailed, but only the beginning of the book is paginated. Malynes listed the English system of weights and measures (p. 37), and the types of English woollen cloths with their legal sizes and weights (p.42). He showed how the named local varieties of cloth were rated relative to Broadcloth for payment of customs duty (p.139), and how Woad was measured (p.36).

The appendix has an essay called '*An Easie Partable Account between Three Dyers: which may serve as an Introduction to Beginners and, being well understood, affords sufficient variety and knowledge for the Stating of Accounts of most Partnerships'*. The hypothetical dyers "*enter into an equal Copartnership*" on 15th January 1664, each bringing particular assets and goods. Malynes demonstrated how to keep a '*Wast-Book'* of the Partable Account, recording the date of every transaction made by the partners. Malynes demonstrated how to summarize and balance the accounts near the end of the year.

The following essay was '*A Controversal Accompt, partable between three merchants in an Adventure for the Streight or Levant'*, set in 1674, which itemized the goods they could purchase in England. It began with broadcloths from Simon Segerstone, clothier, and included 20 Yorkshire Gall-Blacks each 28 yards long (at £10 each). The merchants would later "*Lade a cargazoon of Goods on the Ship Neptune, bound for Smirna in the Streights".*

Malynes other books included *Treatise on the Canker of England's Common Wealth* (1601), *St. George for England* (1601), *England's View in the Unmasking of two Paradoxes* (1603), *The Maintenance of Free Trade* (1622), and *The Centre of the Circle of Commerce* (1623). Modern economists are still interested in his views and the reasoning behind them.

(55 A) The Chaloner Family – Alum Patentees in Yorkshire

Sir Thomas Chaloner the younger (d.1615) (TP M#217688) married firstly Elizabeth (nee Fleetwood d.1603) (TP F#217689), daughter of William Fleetwood (TP M#217690), Recorder of London.

Sir Thomas yr. and Elizabeth had three daughters and seven sons. Many died young: Thomas b.1588, Henry (1593-1600), and Arthur (1594-1601). One son, James (c.1602-c.1660) (TP M#468189) married into the Fairfax family in 1637, to Ursula (TP F#468190).

Their eldest son, Sir William Chaloner (1587-1641) (TP, M#217687), became first Baron Chandler of Guisborough but was often abroad, and died in Turkey. The third son, the Reverend Edward Chaloner (1591-1625) (TP, M#468138), principal of Alban Hall at Oxford University, had royal influence since he was Chaplain-in-Ordinary to both James I and Charles I.

Two of the younger sons, Thomas (1592/9-1661) and James (c.1602-1660) later pursued strongly felt grievances against Charles I.

Sir Thomas Chaloner yr. (d.1615) remarried to Judith (nee Blount d.1615) (TP, F#468194). There is no known family relationship between her father William Blount (TP M#468195), of London, and the Mountjoy line.

Judith was the widow of John Gregory (TP M#468196). It is possible that Sarah Blount, whose father was also an otherwise unknown William Blount, was the sister of Judith. Sarah was the third wife of Sir John Smythe (1557-1608), the second son of wealthy 'Customer' (customs official) Thomas Smythe (1522-1591) who held a monopoly over alum imports from1578 to 1581 (HPM, Smythe, 2015).

Judith and Sir Thomas yr. had a daughter called Frances (1612-1692) (TP, F#468197), half sister of the later regicide Thomas Chaloner (d.1661). Through marriage, Frances linked the Chaloner family with the important Fairfax family. In about 1630 she married Sir William Fairfax (1609-1644) (TP M#468198) of Seeton, Yorkshire.

William was the son of Philip Fairfax (b.1582) (TP, M#46866) and Frances Sheffield (1586-1645) (TP, F#479051) (DNB Fairfax P. 18, 943). Frances (nee Chaloner) and William (d.1644) became the parents of Sir William Fairfax (1626-1674) (TP, M#595473). When William's brother Edmund Fairfax died in 1636, he inherited the family estates of Seeton and Newton Kyme. In 1641 he became a Captain in the trained bands led by his uncle Ferdinando Fairfax.

(56 A) The Sheffield Family, Earls of Mulgrave – Alum Patentees in Yorkshire

The name Sheffield was shared by several landed families other than the Mulgraves. There is an absence of any birth or death dates for some individuals, and it was a common practice to use the same first names for successive generations. This causes confusion whenever events involve to a named individual without clarification of their family line. Even modern genealogies show some individuals as having been born before the birth of their supposed father.

John Sheffield (2nd Baron Sheffield) was the son of Edmund Sheffield of Butterwick and Anne de Vere (vide TP F#17050). John married Douglas Howard (DNB, 2004, 50, 162).

Douglas Howard (c.1537-c.1608) (TP F#17050) was the daughter of William Howard, 1st Baron Howard of Effingham, and Margaret nee Gamage. She married three times: firstly in c.1562 to John Sheffield, secondly in 1573 to Robert Dudley, 1st Earl of Leicester, and thirdly in 1579 to Sir Edward Stafford.

She had two children with John Sheffield: Elizabeth (d.1600), and Edmund (d.1646) the first Earl Mulgrave.

Sir Edmund Sheffield, 1st Earl of Mulgrave (1564-1646)

Sir Edmund Sheffield (1564-1646) (TP M#29726), first Earl of Mulgrave (1646) and 3rd Baron Sheffield, was the son of John and Douglas (d.1608).

Sir Edmund was related to the Earl of Huntingdon (q.v.) because his widowed mother, Lady Douglas Sheffield (nee Howard) (1542/3-1608), had given birth to the illegitimate son of Robert Dudley (d. 1588), also called Robert Dudley (1574-1649).

Sir Edmund (d.1646) was Lord Lieutenant of Yorkshire (1603-19) and Vice Admiral of Yorkshire (1604-46). He invested in the Virginia Company and the New England Company.

Sir Edmund married twice; firstly in about 1581 to Ursula Tyrwhitt (d.1618) (TP F#575481). They had six sons and five daughters (Stonehouse, 1839, 270). Three of the daughters were Lady Mary (d.1619) (TP F#29725), Elizabeth (TP M#29726), and Frances Sheffield (d.1615).

Lady Mary Sheffield (d.1619) married Ferdinando Fairfax, 2nd Lord Fairfax of Cameron. Their eldest son was Sir Thomas Fairfax (1612-1671), 3rd Baron Fairfax (1648) of Scotland and Commander in Chief of the New Model Army which defeated King Charles I (Williams, 1980, 138).

Frances (d.1615) married Sir Philip Fairfax (1586-1613) of Steeton, Yorkshire. Their son, Sir William Fairfax (1610-1644) in 1629 married Frances Chaloner (1610-1692/3), the daughter of Sir Thomas Chaloner of Guisborough (DNB, 18, 943). William's elder brother Edmund Fairfax died in 1636 and he inherited the family estates at Steeton and Newton Kyme. In 1641 William became captain of the trained bands led by his uncle Ferdinando

River Ouse Ferry Disaster – 3rd December 1614

Sir Edmund Shaffield (d. 1646) had six sons by Ursula, but all died before becoming Earl Mulgrave. "*Sir John, Edmund, and Philip were drowned in their passage of the Whitgift ferry over the river Ouse, with all their attendants, in December, 1614. George broke his neck in a new riding house, said to have been made out* *of an old consecrated chapel. Edmund William was drowned in France, and Charles the only survivor died a bachelor"* (Stonehouse, 1839, 270).

Among the drowned was the eldest son, called Sir Edmund (d.1614)* (TP M#29726), who had been knighted in 1610. Another son, **Sir John Sheffield** (TP M#575482) and his wife **Grizel nee Anderson** both drowned on the Ouse ferry, but they themselves already had a son **Edmund (1611-1658)** who survived. It was this grandson of Sir Edmund (d.1646) who became the second Earl Mulgrave.

Grizell (TP F#575484) Sheffield was the daughter of Sir Edmund Anderson (TP M#575483).

Confusingly, **Elizabeth Darley**, the widow of the drowned Sir Edmund (d.1614)*, later remarried to a William Sheffield.

William was the son of an unrelated **Sir Edmund Sheffield (+) (c.1566-1615**) **of Epworth**, a quite separate Sheffield family (HPM Sheffield 2015). This Edmund (+) was the son of Robert Sheffield of Epworth and Margaret (nee Frodsham) from Elton in Cheshire. Margaret's aunt had been employed by the dowager Lady Sheffield (Mulgrave) in the 1580s.

Edmund (d.1615) (+) was a gentleman copyholder on the Mulgrave estates in Lincolnshire, and was related through his wife to Sir Thomas Chaloner the younger (d.1565) who had married Ethelreda Frodsham (TP M#468139). He was educated at Cambridge(1584), and Inner Temple (1585) in London.

In 1587 Edmund (+) married Anne, daughter of Gabriel Fairfax of Streeton, Yorkshire. He became MP for Aldborough in 1604, either through the patronage of the 1st Earl of Mulgrave (Edmund 1564-1646, 3rd Baron Sheffield), or the patronage of Thomas Tankard of Brompton Hall, who was married to another of the Frodsham daughters. Edmund (d.1615) was knighted in 1603.

The son of Edmund (+) in Lincolnshire was **William Sheffield (1589/90-1646),** whose mother has been incorrectly called Elizabeth (HPM 2015 Wm. Sheffield). William was educated at Cambridge and Lincoln's Inn (1612) in London. He became was an undistinguished politician, left England at the beginning of the Civil War to live at Delft, and died in Holland (HPM 2015 Wm. Sheffield).

William (d.1646) married twice, firstly in 1615 to **Elizabeth Darley** (d.1633) from Kilnhurst. This was Elizabeth's third marriage. She had first married Henry Topham (d.1612), then secondly Sir Edmund Sheffield (d.1614). William's second wife was Mary (nee Dent) the daughter of John Dent, a London Salter, and widow of Sir Henry Savile of Methley.

Sir Edmund Sheffield (d.1646), first Earl Musgrave, married a second time to Mariana Erwin (Irwin, Irwyn). Some authors have wrongly speculated that Edmund (d.1658) **, second Earl Mulgrave, was his grandson through Mariana's family, or was a son of Sir Edmund (d.1646) himself.

Sir Edmund (d.1646), the first Earl, and Mariana produced two daughters and three sons, James, Thomas and Robert (Stonehouse, 1838, 270). At some stage the family moved its residence from West Butterwick to Normanby.

Sir Edmund Sheffield, 2nd Earl Mulgrave (d.1658)

Sir Edmund (1611-1658)**, grandson of the 1st Earl Mulgrave, grew up as the ward of Arthur Ingram. He married Elizabeth (1607/8-1672) nee Cranfield , a daughter of Lionel Cranfield (d.1645), Earl of Middlesex.

Sir Edmund (d.1658)** became the second Earl Mulgrave, Vice Admiral of Yorkshire (1646) and a member of the Council of State during the Commonwealth.

He helped to get the state monopoly on alum removed in 1648 (HPM E. Sheffield 2015). He declined to serve in Cromwell's Upper House of Parliament in 1658.

John Sheffield (1647-1721), is referred to as the only son of Sir Edmund (d.1658)** and Elizabeth (d.1672). He was a courtier and became the **1st Duke of Buckingham and Normandy** (DNB 2004 50, 166). John became wealthy and built Buckingham House, later renamed Buckingham Palace.

The Mulgrave geneaology published by John Graves seems deliberately obscure (Graves, 1808, 301).

(57 A) The Foulis Family - Scottish gold mining and Yorkshire Alum Patentee

David Foulis came from a Scottish family with experience of the royal finances and of mineral mining, especially of gold, silver and lead prospects in the Crawford Moor and Glengonnar areas of south Lanarkshire.

In the same area, De Vos had been exploring for gold after leaving Mountjoy's alum business in Dorset. Despite interest by historians in the early gold workings of Scotland, many details remain unclear and there is little original, reliable documentation. A small gold mine owned by James IV was operating on Crawford Moor about 1540, under the direction of Sir James Pettigrew (Meighan, 2013).

In 1593 James VI granted to the Edinburgh goldsmith **Thomas Foulis** (c.1560-1628) (DNB, 20, 549) a lease of 21 years on the gold, silver and lead mines of Crawford Moor and Glengonner (Canmore 2015). James at that time owed £14,594 in debts to Foulis, secured against the Crown's gold plate collection.

The Foulis family had already become landed gentry with the purchase of **Colinton estate** near Edinburgh by the lawyer James Foulis (d.1549) (TP M#310821) who was the Lord Clerk Register in Scotland, a judge (1526) and Lord of Session (1532). Details about many of the later family members are sparse.

James Foulis (d.1549) (1) married Catherine (TP F#414596) nee Brown. They had one known son, Henry (2) (TP M#310822), who married Margaret (c. 1545-1560) (TP F#310820), nee Haldane, daughter of Sir James Haldane of Gleneagles.

Henry Foulis (2) had two known sons, James (3a) (TP M#25789) and Thomas (c.1560-1628) (3b) (DNB, 20, 549). Thomas became a goldsmith, royal financier, and mining entrepreneur.

James Foulis (3a) married Agnes (d. 1593) (TP F#414600) nee Heriot, daughter of Robert Heriot of Lumphoy They had two known daughters (MacGregor 2015), and four known sons. In two historical accounts, the name of the fourth son is completely different. This is important because the lead-mining lands which later developed into a major Scottish industry were in the dowry of that son's grand-daughter Anna (TP F#426467).

The daughters of James (d.1549) were Margaret (d.1609) who married Thomas Hamilton (1563-1637), 1st Earl of Haddington (TP M#17762); and Jean who married George Home of Broxmouth.

The **sons of James (d.1549)** (3a) were:

(4a) Sir James Foulis (TP M#414601) of Colinton, whose descendent was David (d.1642) (TP M#414641);

(4b) George Foulis (d.1633) (TP M#414619) of Ravelston, goldsmith and Master of the Mint;

(4c) **Sir David Foulis** (d.1642) (TP M#414641), first baronet of Ingleby, Yorkshire, whose son Robert became a goldsmith apprentice (1617) to Daniel Crawford in Edinburgh;

(4d) **John Foulis** (TP M#414642) who lived at **Leadhills.**

However, Macgregor in 'The Red Book' claims that the fourth son was the advocate (4dd) Robert Foulis, of Southside, Newbattle, rather than John, and that this Robert's daughter Anna married Sir James Hope (MacGregor 2015).

A third version, by George Fothergill in *George Foulis (1569-1633) and the Carved Stones of Ravelstone,* claims there were five sons (ADS 2015). Instead of Sir James, the eldest was Alexander (Bart. 1634) whose son James (d.1688) became Lord Justice-Clerk (1684). The extra son was Robert, an advocate. George the mint master, David the royal courier, and John the youngest son, were all present. In Fothergill's account, John's grand-daughter married Sir John Hope.

Sir David Foulis (4c) married Cordelia nee Fleetwood (d.1631) (TP F#658661), the daughter of William Fleetwood. Sir David was employed by his uncle, the goldsmith Thomas (3b), as a royal courier.

Sir David became wealthy, and was one of the original alum patentees in Yorkshire. He was succeeded in turn by his son Sir Henry (1607-43) (TP M#658663), and grandson Sir David (1633-1694/5) (TP M#468206).

John Foulis (4d) (TP M#414642) at Leadhills was probably managing the lead mines on behalf of his uncle, the goldsmith Thomas (3b).

John's son Robert (TP M#426468) also lived at Leadhills, probably assisting at the mines. Robert had a daughter called **Anne** (TP F#426467). This Anne married **Sir James Hope** (1614-1661)(TP M#346446), who later called himself 'Sir James Hope of Hopetoun'. The two sons of Anne and Sir James were John Hope of Hopetoun (1650-1682) and William Hope of Kirkliston (1660-1724).

Thomas Foulis (c. 1560-1628)

Thomas Foulis (d.1628) (3b) became apprenticed to the skilled **goldsmith** Michael Gilbert. He also studied the trade in France (1578-9) before beginning his own business in 1581 in Edinburgh. He became a burgess of Edinburgh in June 1581 "by right of his master Martin Gilbert" (MacGregor, 2015). The city goldsmiths were only a small group (Smout, 1972, 161).

Thomas was soon appointed as the 'Sinker' designing sinking-irons for the Royal Mint (1584-1614). He also designed coins and seals, and became the royal financier to James VI of Scotland. He opened an agency in London. From 1591 he handled the subsidies being paid by Elizabeth I of England to King James, and employed as his courier David Foulis (d.1642) (4c). This laid the foundation for David's later career as a courtier.

In 1593 James VI granted to the Edinburgh goldsmith **Thomas Foulis** (c.1560-1628) (3b) (DNB, 20, 549; Clow & Clow 1952, 24) a lease of 21 years on the gold, silver and lead mines of Crawford Moor and Glengonner (Canmore 2015). During 1593 Thomas Foulis opened the Lanarkshire lead mines called 'Friar Muir of Glengonnar', employed foreign mining technicians, and developed what became the renowned Leadhills mining district.

In 1597 he worked the gold mines, but was harassed by the lawless Border Reivers, "the broken men of the Borders" (Meason, 1827, 42). The mining engineer Gavin Smith, in a letter of 1598 to Cecil, stated that Thomas Foulis had visited the north of England in 1598 to gain advice about mining techniques (Carlton, 1840, 4, 99). He consulted Smith, and later hired Bevis Bulmer.

Thomas later formed a partnership with the Englishman **George Bowes** (Lindsay, 1877, 4, 259). George had experience of the Borders, and probably made good security arrangements.

About 1606 English miners under the direction of **Bevis Bulmer** (1536-1615) were employed by George Bowes (1527-1580) to open pits in Ettrick forest. Like De Vos, Bulmer was a member of the Mines Royal (1568-1603), as was Bowes (Skepton, 2002, 99).

A silver mine was opened at **Hilderstron, near Linlithgow**, in 1607 (Meason, 1827, 42).. From 1608 to 1611 Bevis Bulmer ran Hilderstron Mine very successfully for the Scottish Crown. In 1613 the Crown awarded the right to operate the mine to a partnership of Sir William Alexander, Thomas Foulis, and the Portuguese investor Paulo Pinto. Their rent to the Crown was one tenth of the refined ore produced. The vein was soon exhausted.

Although published accounts of early gold mining in Scotland contain many dubious details, Acts of Parliament do verify the roles of Thomas Foulis (January 1593), and Stevin (sic) Atkinson (June 1616), and a royal contract of March 1567 is extant for De Vos (Lindsay, 1877, 4, 350).

The **banking business of Thomas Foulis** (d.1628) gradually became over extended. King James began to keep his English subsidy granted by Elizabeth I in Foulis's account, but also become heavily overdrawn. Political intrigues delayed his repayments.

Foulis had to raise credit to cover his commitment, had a **nervous breakdown in 1598** when he was bankrupt. Not until 1606 did Parliament raise a tax to repay most of the royal debts owed to Thomas and his associate Jowsie. Thomas spent the interveening time **helping to run Hilderstone silver mine** for his relative, Thomas Hamilton. He patented a new process for extracting silver from lead ore in 1613, and prospected for gold on Crawford Moor.

At some stage, possibly during the financial difficulties of 1598, Thomas was able to transfer ownership of his mineral lands near Leadhills either to his nephew John Foulis (4d) or to John's heir Robert (TP M#426468). Both of them lived at Leadhills, and may have been mine managers. That ownership later passed to Robert's daughter Ann (TP F#426467). This heiress was married in 1638 to **Sir James Hope (1614-1661),** later called 'Hope of Hopetoun' (DNB, 28, 15).

The **Hope family** descended from John Hope ('Petit Johnne', or the 'Trumpetour'), an Edinburgh burgess (1516/17) and merchant. His son was Sir Thomas Hope (1573-1646) of Craighall, who became Lord Advocate (1626) to Charles I. The fourth son of Sir Thomas (d.1646) was Sir James Hope (d.1661), who studied law in France (1636), and styled himself 'of Hopetoun' (the old name for Leadhills) after marrying Ann nee Foulis. He followed a legal career and became an Ordinary Lord of Session (1649), but also actively developed the lead mines. He had interests in technology, shipping and trade, and became Master of the Mint (1641). He died of 'Flanders fever' after visiting Holland on business connected with the lead mines. His son John Hope (1650-82) bought land at Abercorn, near South Queensferry. There, on the Firth of Forth, Sir James's widow Margaret Hamilton built **Hopetoun House** in 1699-1707 which is still an impressive mansion (Hopetoun 2015).

Sir David Foulis (d.1642) (TP M#414641) was knighted in 1603, gained an M.A. at Oxford University, and was appointed cofferer to Henry Prince of Wales, the next highest post to comptroller of the household (Graves, 1808, 249). Thomas Chaloner may well have personally recruited David Foulis to the Yorkshire alum project while both were members of **Prince Henry's household**, where Thomas acted as tutor to the Prince. Sir David became a baronet in 1619, and cofferer to Prince Charles. From the Crown he received the manors of Greenhowe and Templehurst, and in 1609 purchased the manors of Ingleby and Battersby from Ralph Lord Eure (Young, 1817, 2, 827). He lived at **Ingleby,** once the main residence of the Lords Eure, and served as a Justice of the Peace, and a member of the Council for the North. John Graves in 1808 published a genealogy of the Foulis family , but recorded Sir David's death as being in 1631 (Graves, 1808, 249).

In 1633 Sir David was censured by the Star Chamber for his **opposition to Lord Wentworth**, who was President of the Council for the North. He lost all his official positions, and together with his son Henry was imprisoned in the Fleet. Sir David then had to pay fines of £5,000 to the King and £3,000 to Wentworth, while Henry paid £500 (Graves, 1808, 249; Young, 1817, 2, 828).

(58 A) Gold and Lead Mining is Scotland – Cornelius De Vos and Thomas Foulis

The early Scottish gold industry was secretive, and there seem to be few reliable early documents extant. Cornelius De Vos in particular remains a shadowy figure. Atkinson in 1619 called him "*Mr Cornelius, a lapidary in London*" (Calvert, 1853, 143). Elsewhere he is known as 'Devoz'.

In 1827 members of the Bannatyne Club in Edinburgh received a booklet containing Gilbert. L. Meason's 'Account of a Curious Manuscript Volume entitled '***The Discoverie and Historie of the Gold Mynes in Scotland, Written in the Year 1619. By Stephen Atkinson'*** (Meason, 1827, 37-47). The Bannatyne Club (1823-67) had been founded by Sir Walter Scott to publish works of Scottish interest. Founding members included wealthy intellectuals like John Clerk (Lord Elgin), Henry Cockburn, and Robert Dundas of Arniston.

Atkinson's account is the most important record of early gold mining in Scotland. He was well informed. He had been a gold refiner at the Royal Mint in London before assisting Bevis Bulmer prospecting for gold in Scotland.

Meason claimed that the study of **alchemy by James IV** of Scotland led to the king's interest in mining. His **gold mines on Crawford Moor** were probably the first in Scotland. These 'mines' were shallow diggings exploiting placer deposits formed in unlithified sediments by modern rivers, and did not require rock excavation. The gold had originally come from rock veins exposed and fragmented by erosion millennia earlier. It had then been transported by water and re-deposited in alluvium, regarded in 1616 as remains of a Biblical Flood (Meason, 1827, 38).

Lead, however**,** had been mined from actual mineral veins at Leadhills in the Southern Uplands from the early medieval period. Boundaries delineated there in a 1239 charter to the monks of Newbotle (Newbattle) abbey indicate lead workings (Chalmers, 1807, 1, 794). A significant amount of lead was found at Leadhills in 1513 by **Martin Templeton**, and lead mines were opened by George Douglas of Parkhead (Clow & Clow, 1952, 365.

To promote the search for precious metals, **James IV** brought prospectors to Scotland from Germany and Holland in 1526, and from Lorraine in 1539-42 (Lindsay, 1877, 4, 257). A company of Germans and Dutchmen obtained a 21 year lease on the gold and silver mines of Scotland from James V in 1526 (Meason, 1827, 40).

These Germans may have been organised by **Joachim Hochstetter**, probably the wealthy Augsberg financier who was a business associate of the Gresham mercantile family in London (Scott, 1910, 2, 407). Eric Ash states that this Joachim was the father of Daniel Hoechstetter, who later played a prominent role in establishing the Company of Mines Royal in England (Ash, 2004, 46). But within a few years Joachim abandoned the location and returned to the Tyroll (Ash, 2004, 46).

The German company employed 300 men, and in three years reputedly obtained gold worth £100,000 sterling. Most of this was probably from Crawford Moor, although new workings were opened in the Pentland Hills, Langham Water and Megget Water.

A small gold mine owned by the King was operating on **Crawford Moor** in about **1540,** under the direction of **Sir James Pettigrew** (Meighan, 2013). A French account of 1710 claimed that this mine too had been opened by Germans (Dudgeon, 1874). James reputedly employed English and Dutch artisans for refining and smelting the ores. Documented payments made by the Scottish Crown to Pettigrew in 1511-13, for his workmen, authenticate the existence of this mine (Dudgeon, 1874).

In 1568 **James Stewart (c.1531-1570, Earl of Moray**, acting in his capacity as Regent (1567-70) on behalf of the infant King James V of Scotland, gave **De Vos** (De Vois) a 19 year license to seek minerals on Crawford Moor (Meikle; Minexplorer, 2015). After leaving Dorset and England in about 1565 de Vos (qv) had ostensibly returned to Liege, deserting his London wife Helen Gylmyn (Turton, 1958 39). By 1567 he was already in Scotland.

1567 Newhaven Saltworks opened by Cornelius de Vos

Edinburgh burgh records show that, in June 1567 the partnership of Cornelius de Vos, Anthony Hickman, and John Achille was granted a fifty year lease of coastal land at nearby **Newhaven** to establish salt-pans (RBE 1567).

"12 May 1567 Salt pannis at Newhavin

[The bailies, council and deacons of crafts,] *allin one voce, findis gude and consenttis that ane pairt of their Newhavin be set in tak to Antonie Hikman, Jhone Achille and Cornelius du Vois, Inglischemen, for the spaceo of fyfftie yeris, and that the commoun sele of this burgh bu hungyn thairto*".

On 16th May a committee of fourteen members was appointed to view and measure the ground of the proposed saltworks. It was on the south side of Newhaven and "*contenand twentie thre fall of lengthe and sextene fall in breid, ilk fall contenand sex elnis Scottis*", they reported on 4th June.. On 18th June the grant was confirmed, covering three tacks for the successive periods of 19, 19, and 12 years".

Coal was probably used to heat the brine for evaporation in large pans. There is one account of deep coal mines at Newhaven by 1609, but this may be a mistake for well known Culross mines on the opposite side of the Forth (Turnock, 2005, 24). Before 1618, John Taylor visited a coal mine built by George Bruce of Culross on the foreshore, entered through an annular stone revetment to keep out the sea. That coal was at a depth of forty feet, and over a period of about 29 years the seam had been followed for a mile out below the sea. It supplied his saltworks which made about 90 tons a week. The salt "*doth serve most part of Scotland, [and] some he sends into England, and very much into Germany"* (Taylor, 1618, 44).

Meason (1827) incorrectly claimed **Cornelius De Vos** to have been an artist and dated his arrival in Scotland as between 1580 and 1592. He stated that early in the reign of James VI "*two Dutch painters, De Vos and Bronkhorst (brought over to execute the pictures in the gallery of Holyrood-house), entered into a partnership to work the gold mines of Scotland. Nichlas Hilliard, jeweller to Queen Elizabeth, is also a mining adventurer in this region*" (Meason, 1827, 40). Carleton repeated this story in 1840 (Carleton, 1840, 4, 95).

Some historians have dismissed the art connection as a simple confusion between the name of the mineral prospector and a well known artist. The painter **Cornelis de Vos (1584-1651**), from Antwerp, was a frequent collaborator with Rubens, and is most unlikely to have visited Scotland. The painters Daniel De Vos and Van Overbecke, from Antwerp, were employed in London in June 1603, on a Dutch Arch for King James's Coronation (Wiggins & Richardson, 2015, 1604)

Arnold Bronckhorst (Bronkorst, flourished 1585-1583) was a friend of the London painter **Nicholas Hilliard** (c. 1547-1619), and Nicholas is known to have invested in gold mining. Nicholas Hilliard was a goldsmith from Exeter, who became a renowned London painter of miniature portraits, and a jeweller to Elizabeth I. He travelled to France to study, from 1576 to 1578/8, and after returning to London he did put money into a scheme for gold mining in Scotland. He lost a significant investment (Strong, 1997, 17).

The involvement of Hilliard and probably Bronckhorst in gold mining makes their possible association with the merchant and prospector **Cornelius De Vos** quite plausible.

Bronckhorst himself received £130 Scots in 1580 for a portrait painted in Scotland of James VI. One possibility is that De Vos had found it expedient to pose as an artist and companion of Bronkhurst while he was travelling to Scotland. Subterfuge was commonplace in the business of mining precious metals. Atkinson in 1619 called him "*Mr Cornelius, a lapidary in London*" (Calvert, 1853, 143). Elsewhere he is 'Devoz'.

In Atkinson's account, **De Vos** "*was sent thither to discover the golden bedd or vaine, at the charge* (instructions*) of certaine merchants in London, who procured unto him **Queen Elizabeth's signett** (*letter of recommendation) *unto the* (Scottish*) king's majesty*" (Meason, 1827, 40).

This **claim, that De Vos was acting under instructions** from the English Crown to find the 'mother lode', the source of the placer gold, cannot be substantiated. It has been claimed that he wrote from Scotland to Sir Lionel Duckett (d.1587), Master of the Mines Royal (1568) (qv). This has been taken to suggest that the Mines Royal organization had a covert connection with the venture. Although this remains a possibility, documentary proof is missing.

De Voz did consult with German employees of the Mines Royal at Keswick. The English overseer there reported this anxiously to Robert Cecil, but de Voz seems to have been in a covert private capacity . The Germans claimed later to have provided him with false information.

Eric Ash has examined the role of De Vos in Scotland and claimed that he was in effect double crossing the Mines Royal (Ash, 2004, 45). The other English partners in his Scottish adventure may have been in a similar position, which would explain the need for elaborate deceptions around the presence of De Vos in Scotland.

Edinburgh Gold Mining Partnership

Atkinson (1619) recorded that De Vos visited "*mountains in Clidesdale* (Clydesdale) *and Nydesdale*" before he showed to "*his friends at Edenborough … the natural gold, which he called the temptable gold*", to persuade them to invest in the venture.

A gold production company was set up in Edinburgh. Forty five shares in the Edinburgh gold mining partnership were issued: 10 went to the **Earl of Morton**, 10 to **Robert Ballentine** the secretary to the partners, 10 to **Abraham Paterson** (a Dutch man living in Edinburgh), 5 to **James Rede** (an Edinburgh burgess), and 10 were retained by **De Vos and his London partners**.

The capital was L. 5000 Scots, but some of this was paid in goods instead of cash: "*Some brought corne, some victuals, and some malt or meal, besides monies*". This partnership was deemed necessary by De Vos for "*gaining favour in high places and obtaining a relaxation of the bullion laws which prohibited the exportation of precious metals, except for the payment of imports and the needful expenses of travel*" (Carleton, 1840, 4, 95).

Instead of vein gold, De Vos had only found more **placer deposits**. He reputedly employed 180 poor people, young and old, in an organised search of river valleys for gold grains in stream beds. In just over one month he apparently supplied the Scottish mint with viij pounds of gold, worth £450 Stirling.

There is confusion over how long de Vos remained in Scotland. The **Earl of Morton,** still as Regent, instructed De Vos to take all the gold found at Crawford Moor to the **Edinburgh Mint.** It was used to make coins with a value of £ iij, each containing one (Troy) ounce of gold (Morton 1827, 41). That demand may have been made in 1575, when Morton instructed James MacGill (d.1579) of Nether Rankeillour in Fife, the Lord Clerk Register (Keeper of the Scots Royal Archives), to re-negotiate the Crown's gold and silver mining contract with De Vos.

Carlton (1840) claims that De Vos returned to London in 1572 after assigning the partnership rights of himself and his English partners to the artist Bronckhourst, who undertook to forward the profits. The King refused to acknowledge their agreement and no remittances went to London (Carleton, 1840, 4, 97). That deterred any further investment from England. In 1576 the Scots Privy Council ordered Roberton and Henderland to stop exporting gold (Meason, 1827, 40). They seem to have been at Crawford Moor, and may have been connected with the Edinburgh gold mining company.

Arnold Bronckourst did reputedly have correspondence in 1579 with **George Bowes** (1527-1580) in England. George was a mining promoter and brother of the diplomat Robert Bowes (c.1535-1597). They were sons of Richard Bowes (d.1558) and Elizabeth nee Aske.

Sir George Bowes (d.1580) of Streetlam, County Durham, was Marshal of Berwick upon Tweed (1558-61), a soldier, land speculator, and mining entrepreneur (HPM, Bowes, 2015). Robert Bowes (d.1597) was Sheriff of County Durham (1569), Treasurer of Berwick (1578) and had served as an English diplomat in Edinburgh (1577-83).

But George Bowes did not acquire Scottish mining interests until much later (Calvert, 1855, 145-6). The actual letter of April 1579 has been published. It was from "*an anonymous correspondent to Sir George Bowes"* and is most unlikely to be from Bronckourst. (Tytler, 1842, 8, 416). The author details political developments in Scotland, with a comment that "*the Flemish painter is in Stirling, in working of the King's portraiture"*, and the author would not refer to himself as "*the Flemish painter*" (Tytler, 1842, 8, 418).

Gold Panning:

The simple **gold-panning techniques** used along Scottish valleys in 1616 were probably unchanged from those employed by De Vos. They "*make a long sowgh, or scouring place, into which they bring the streame water, to scower away the light earth from the heavy sand earth, and to cull away* (discard*) the great stones from the heavy sands, which sand or heavy earth they scrape into their trough or tray, and by stirring it, and washing the same often, there is found both raine gold, flat gold, pale gold., and blacke gold"* (Meason, 1827, 39).

De Vos was followed at Crawford Moor by another Dutch prospector, **Abram (Abraham) Gray** (Meason, 1827, 41; Lindsay, 1877, 4, 258). He was assisted by other Dutchmen from London, as well as English artisans. Known as '**Greybeard'**, Abram made a significant gold find at Wanlockhead. A golden bowl and coins called 'unicorns', both reputedly made from this gold, were presented to impress the King of France (Meason, 1827, 41).

In a different version of events, Cochran-Patrick (1878) claims the De Vos partnership in 1572 assigned its rights directly to Arnold von Bronckhorst, who in turn soon transferred them to **Abraham Peterson** (not Gray). Peterson was supposedly a 'German' known as 'Greybeard' and an original member of the De Vos partnership. Peterson sold his property in Edinburgh to raise capital, and obtained more from other 'Germans'. His mines were successful for several years (Cochran-Patrick, 1878).

In 1583 James VI granted a new 21 year licence to search for gold, silver, copper, tin and lead in Scotland to **Eustacius Roche** from France. He set up a joint stock company, which soon failed after heavy losses (Scott, 1910, 2. 408).

The Scots Parliament delayed an Act to confirm Roche's license until 1584, because after the departure of Peterson, the King and nobles had begun "*to let the said hail (*good*) mines within their dominions to one or* *two strangers for a small duty*" (Carleton, 1840, 4, 97). Those lease holders could not afford to operate mines effectively, but refused to "*instruct other lieges of the county (*sic*) in that knowledge*".

The Master of the Scottish Mint, John Lindsay from Edzell in Forfar, and his elder brother Sir David Lindsay, began looking for gold at Crawford Moor in 1592 (Lindsay, 1877, 4, 258). To regulate the mining of precious metals, the Scots Parliament decided in 1592 to create the new office of **'Master of the Metals'** , to be occupied by an expert who would advise them on the granting of mining privileges. **Sir Beavis Bulmer** was appointed (Scott, 1910, 2, 409).

Improved English methods of **lead working** may have been introduced into Scotland in 1585 by **George Douglas** of Parkhead on Douglas Water (Carleton, 1840, 4, 99). When his lands were forfeited in 1561, Douglas and his sons James and George took refuge in the north of England, where they studied the new techniques in lead mining. After his lands were restored by the Crown in 1585, mining began at Shorteleuch, where gold was also found. George Douglas died in a mine collapse.

The English **lead industry** had been greatly improved during the 1570s by the use of a 'German sieve' for processing ore, and water-powered lead-smelting furnaces. These had been invented and patented by **William Humfrey** (c.1515-1579), a London goldsmith and assay master at the Royal Mint, and Christopher Schultz (1521-1592), leading members of the Company of Mineral and Battery Works. Their patents were widely disregarded.

In 1593 James VI granted to the Edinburgh goldsmith **Thomas Foulis** (**c.1560-1628**) (qv) (DNB, 20, 549) a lease of 21 years on the gold, silver and lead mines of Crawford Moor and Glengonner (Canmore 2015). During 1593 Thomas Foulis began to work the Lanarkshire lead mines called 'Friar Muir of Glengonnar'. He later employed foreign mining technicians, and developed what became the renowned Leadhills mining district.

In 1597 as Foulis worked the gold mines, he was harassed by the lawless Border Reivers, "the broken men of the Borders" (Meason, 1827, 42). The mining engineer Gavin Smith, in a letter of 1598 to Cecil, stated that Thomas Foulis had visited the north of England in 1598 to gain advice about mining techniques (Carlton, 1840, 4, 99). He consulted Smith, but later hired **Bevis Bulmer (1536-1615).**

Thomas Foulis formed a partnership with the **Sir George Bowes** (d.1580) (Lindsay, 1877, 4, 259). Sir George had much experience of the Borders, and probably made good security arrangements. He sent his younger son, also George, to Wanlockhead in 1603 as a mineral prospector to assist Sir Bevis Bulmer.

At some time, possibly before 1593, a **George Bowes** (possibly an associate of the Mines Royal) found a small vein of gold at Wanlockhead. He anounced this but was careful to keep the location secret. It remained unknown due to his death soon afterwards, falling from a faulty ladder while visiting the Keswick copper mines (Meason, 1827, 41). If the dates are inaccurate, this could have been Sir George's son.

Sir George's older son was Sir William Bowes (d.1611), who served as Warden of the West March, Treasurer of Berwick, and English ambassador to Edinburgh where he was expected to monitor the activities of Englishmen visiting Scotland.

About 1606 English miners under the direction of **Bevis Bulmer (1536-1615**) were employed by **Sir George Bowes** (1527-1580) to open pits in Ettrick forest. Like De Vos, Bulmer annd Bowes were members of the Company of Mines Royal (1568-1603) (Skepton, 2002, 99). Beavis Bulmer was probably the son of Sir John Bulmer and Margaret Stafford, who were both barbarously executed in 1537 for treason, having joined a rebellion called the Pilgrimage of Grace. Bulmer was an infant then. His elder brother Ralph, although also guilty, had been pardoned.

Bevis Bulmer studied the technology in Georgius Agricols's handbook *De Re Metallica (*1555*),* and may have gained metallurgical experience at Sir John Manners's iron smelter, at Rievaulx Abbey. He had probably visited Schultz's smelter at Deptford.

In 1562 Bulmer had opened lead and calamine mines near Chewton in the Mendip Hills of Somerset. Those ores were processed from 1565 to 1586 by Christopher Schultz in a smelter built at Tintern for the Company of Mineral and Battery Works. Bulmer was an inventor. In 1581 he patented a water-powered machine to make nails. From 1593 to 1595 he built a pumped system to supply drinking water from the Thames to Cheapside.

Stephen Atkinson began his association with Bevis Bulmer late in the sixteenth century. He had begun his career as an apprentice to Francis Tiver, a refiner of gold and silver. In about 1586 Atkinson became a refiner at the Tower of London Mint. He later refined silver in Devonshire, from Irish lead. He spent two years working in Ireland for Bulmer (Meason, 1827, 45). He was taught prospecting by Bulmer, and later became his partner.

Atkinson's **1619 account of the Scottish goldfields** was apparently based on a lost document written by Bulmer himself called **'*Bulmer's Skill*'** (Calvert, 1855, 149). He described the area as "*God's treasure House*". In 1616 Atkinson was appointed by the English Privy Council to replace Bulmer at the Crawford Moor mines (Lindsay, 1877, 4, 265). **Queen Elizabeth I reputedly gave Bulmer letters of recommendation** for the Scottish venture. Bulmer built a stamping mill at Longcleuch (Lindsay, 1877, 4, 260). This was probably an 'Anacango' mill, like a Cornish plash-mill, designed to recover small quantities of gold from solid rock by breaking the vein matrix (Lindsay, 1877, 4, 308).

Bowes's miners were the first to find gold in vein quartz at Wanlockhead (Lindsay, 1877, 259). Gold was recovered but apparently not in the quantities expected. In Meason's account, Bulmer built no water-leats or workmen's houses, and only recovered enough gold to present a golden 'porringer' to Queen Elizabeth. (Meason, 1827, 42). Others state that Bulmer built himself a mansion at Glengonar, and workmen's houses at Wanlockhead (Lindsay, 1877, 4, 260, Calvert, 1853, 160)).

A **silver mine** was opened at **Hilderstron,** near Linlithgow, in 1607 (Meason, 1827, 42). Ten tons of ore were sent to England to be assayed and refined by Atkinson at the Tower of London Mint. From 1608 to 1611 Bevis Bulmer ran Hilderstron Mine very successfully for the Scottish Crown. In 1613 the Crown awarded the right to operate the mine to a partnership of **Sir William Alexander**, **Thomas Foulis**, and the Portuguese investor **Paulo Pinto**. Their rent to the Crown was one tenth of the refined ore produced. The vein was soon exhausted.

Mines did not use **gunpowder** for excavation until much later. One of the earliest occasions in England was when Prince Rupert (1619-1682), Count Palatinate of the Rhine and grandson of James I, took German experts to Ecton Mines in Staffordshire to teach the use of gunpowder (Bense, 2013, 125).

Atkinson himself obtained a licence in 1616 to explore Crawford Moor for gold and silver, in return for one tenth of any ore going to the Crown (Meason, 1827, 45). His history of the gold mines was probably an attempt to persuade the Crown to invest in the project. He received no encouragement and may soon have abandoned the project.

He wrote that Bevis Bulmer had been extravagant, "*wasted much himself*", became "*impoverished, and followed other idle veniall vices to his dying day, that were not allowable of God nor man*" (Meason, 1827, 46). Bulmer was said to have died at 'Awstinmoore' in Ireland, with debts of £340 Stirling.

Gold prospecting around Crawford Moor, Friar Moor and Crawfordjohn resumed in 1621 when the physician Dr. John Hyndlie received a licence, but there were no further developments (Lindsay, 1877, 262).

Nearby at **Wanlockhead** the **new lead mines** that opened after 1603 had prospered (Meikle). Accounts of early gold mining in Scotland contain many dubious details, but Acts of Parliament verify the roles of Thomas Foulis (January 1593), and Stevin (sic) Atkinson (June 1616), while a royal contract of March 1567 is extant for De Vos (Lindsay, 1877, 4, 350). Further details on Thomas Foulis (d.1628) are given above (Appendix 49 A)

(59 A) Sir John Bourchier – Yorkshire Alum Patentee

Sir John Bourchier (Bowcher, 1567/8-1626) of Hanging Grimston was the most enigmatic of the original alum patentees. An energetic wheeler-dealer, Bourchier was also the most energetic and financially insecure patentee. He should not be confused with Oliver Cromwell's regicide nephew, the Puritan Sir John Bouchier (c.1595-1660).

John (d.1626) was the second son of Sir Ralph Bourchier (d. 1598) of Beningborough, Yorkshire, and Elizabeth, the daughter of Francis Hall of Grantham, Lincolnshire (HPM Bourchier 2015). His paternal grandfather was an illegitimate son of the second Baron Berners. Elizabeth's brother was probably the M.P. Arthur Hall (1539-1605) of Grantham, a reckless gambler and probably insane. Arthur (d.1605) was imprisoned at various times, for pernicious publications, in the Tower of London, Marshalsea, and Fleet prisons, and probably died in prison (HPM, Hall, 2015).

John's older brother married the sister of Sir Francis Barrington, but was declared a lunatic and his property went into administration by the Barrington family.

John studied law in London at Grey's Inn. By 1588 he had married Elizabeth Verney (c.1566-1612), daughter of George Verney (d.1594) of Compton Verney in Warwickshire. Her brother was the J.P. and M.P. Sir Richard Verney (1564-1630).

Neither George Verney or his son Richard had any money with which to pay a dowry to Bouchier. Later Sir Richard restored the Verney family fortunes by marrying Margaret, daughter of the wealthy Sir Fulke Grenville of Warwickshire.

His own father Sir Ralph (d.1598) also had no capital to give John, who instead received the manor of Hanging Grimston

John and Elizabeth had eight sons and four daughters (Richardson, 2011, 364): Ralph (born c. 1588), Mary M. (born c.1593), Elizabeth (who married Richard Rossiter), Henry (b.c.1595), Robert (b.c. 1597), Verney (later Lieutenant Verney, b.c.1599), Lucy (b.c. 1604), James (b.c. 1605), Catherine (b.c.1608), George (b.c. 1609) and William (b.c. 1610) (Richardson, 2011, 290). The daughter of Mary M. (b.c. 1592) and Jabez Whitaker was the first of the family to go to the Unites States of America, and died in Virginia.

Hanging Grimston manor had been converted into very profitable sheep pastures in the 1580s. John raised £9,500 capital for other ventures by selling half of the manor in 1623. At 15 years' purchase price, that half must have given a revenue of £600 per year.

John used the capital to rent estates to keep more sheep, and began speculating in property deals with landowners who were already deeply in debt. Complex legal arrangements were made.

In 1598 he made the large land purchase of Newton-Upon-Ouse manor, by compensating all but one claimant over the land. That problem was resolved when the man died, but his share went to the Crown. In 1615 Bourchier finally lost the manor to the Crown, which gave it to Suffolk (the Lord Treasurer), who sold it to the wealthy alum 'farmer' Sir Arthur Ingram (HPM, Bourchier, 2015).

Bourchier had rented out this manor, and other lands he acquired, at very high rates.

In 1602 he took a 21 year lease of Seamer Manor near Scarborough, for £700 cash and a rent of £30 per year from John Thornborough (HPM, Bourchier, 2015). This seems to have been a concealed loan, on which interest was paid by Thornborough in the form of a vastly undervalued annual rent. Bourchier himself sublet the land at £130 per year (HPM, Bourchier, 2015).

It is probable that his extensive network of financial contacts made him aware of the alum production project at Slape Wathe as soon as it began. He took decisive steps to intervene with hired technical expertise at the critical early phase of development.

His land dealings had led to contacts with London financiers, who may have helped him to become an alum patentee in 1606/7 (HPM, Bourchier, 2015).

In 1610, as a partner with William Turner, he leased the brassworks of the Mineral and Battery Company at Maidstone and Lambeth. This business failed in 1621.

In 1610 Bourchier was arrested as a result of having helped his cousin Arthur Hall to mortgage his Lincolnshire estates in 1602 to a wealthy London grocer from Yorkshire, Richard Burrell (d. 1629) (Pele, 1905, 267; Cook, 67). Bourchier had underwritten the agreement with a bond for £3600. Hall fell into arrears, and Burrell refused to buy the land to offset the debt. Bourchier was unwilling to forfeit the bond, but eventually had to pay £1360 to Burrell, and issue a new bond of £1,500 against future debts by Hall (HPM Bouchier 2015).

By 1613 Bouchier was in serious financial difficulties. The alum 'farmers' had become bankrupt in 1612, and arrangements by the Crown to reimburse them were very slow. He was not finally discharged from this debt until 1622 (Price, 1906, 93).

During 1613, he was sued for misappropriating £2,000 of goods owned by his deceased financial agent, Robert Gibson of York. To raise funds, he mortgaged part of Hanging Grimston estate for £1,000, borrowed £500 from his former alum 'farm' partner William Turner, and leased out Newton-upon-Ouse manor to two York lawyers, Sir George and John Ellis (HPM, Bourchier, 2 015).

In 1614 he became MP for Hull, despite being unqualified as an outlaw. The seat was in the gift of the first Earl of Mulgrave, his fellow alum patentee. That year, with Mulgrave, he took a patent for making copper by dissolving the ore in water. This failed to work.

In 1620 John Bourchier was one of the Adventurers for Virginia (Richardson, 2011, 364; Belknap, 1831,1, 3). He may have held a partnership in the monopoly over fishing in American coastal waters which was held by Sir Ferdinando Gorges (c.1568-1647), a member of the New England Company (1625) and governor there in 1637 (HPM Gorges 2015). In 1621 Devon fishermen complained strongly about that monopoly.

During 1620 Sir John Bourchier, Sir John Brookes, Edmund Lord Sheffield, Edward Lord Gorges, Sir Ferdinando Gorges, and Henry Bourchier had been among the forty members of "*the council established at Plymouth, in the county of Devon, for the planting, ruling and governing of New-England, in America*" between 40 degrees north and 48 degrees north (Farmer, 1831, 3; HPM 2004 Gorges; Perc, 1990, 139).

In 1621 Bourchier was again outlawed for debt over a scheme to transport animal skins to the north of England.

In 1623, with help from the wealthy businessman Sir Paul Pindar, he tried to acquire from the Crown the entire alum 'farm' together with a 'farm' of the manufacture soap (Price, 1906, 93). Bourchier had a patent to use English potash or wood ashes for the making of soap, rather than using imported ashes which were normally employed.

The idea of a soap monopoly was new, and was later to became important to Charles I. Bourchier hoped to persuade James I that a Crown monopoly over the profitable soap business would offset the problems with alum. "*The king had tried in vain to withdraw from his alum business, but it always came back into his hands*…[so] *why not redeem it or conceal its miserable plight by consolidating it with a young and healthy project"* (Price, 1906, 93).

A bribe of £2,000 per year from alum profits was promised to the Secretary of State, Sir Edward Conway (c.1563-1631) of Ragley (later Viscount Conway of Conway Castle), for approval of the proposal (Price, 1906, 93). Conway had been an adventurous military campaigner on the Continent, and soon became Vice Admiral of Hampshire and the Isle of Wight (1624-31) (HPM Conway 2015).

The bribe was later raised to £4,000, with a promise also of £6,000 per year to the King who would also receive Sir Paul's largest diamond, worth £35,000. King James was shown the diamond and did not return it. He later 'purchased' it for just £18,000 which was to be repaid out of the Crown's alum profits. But the existing alum 'farmer' Sir Arthur Ingram refused to relinquish his lease.

Bourchier refused to give up his soap project, and invested heavily in it (Fedorowicz, 1980, 115; BRC, 1940, 10, 8). His protégés Roger Jones and Andrew Palmer obtained a patent in 1623 to make hard soap (Price, 1907, 207). They had the right to search all soaphouses to prevent infringement of the patent (Price, 1907, 119).

The London soapmakers objected, and Conway wrote to the Mayor to claim it was an important national issue in order to improve "the balance of trade" with foreign countries. This was a newly popular concept (Price, 1906, 119).

A public trial of the patent soap in London showed it was suitable for coarse linen, but physically harmed fine linen. It was also questionable whether all the ingredients were English (Price, 1906, 119).

Bourchier raised capital by selling half of Hanging Grimstone manor to Sir Arthur Cockayne. To stifle opposition to his plan of using English potash, he bought £9,000 of stock in the Eastland Company which imported Baltic potash.

London soap makers still opposed his plan. In 1624 he invested £1,000 in a one-sixth share of his new London Soapmakers Company. He persuaded Cockayne to invest heavily. During 1624 he spent £5,000 on the project, and bought a second share in 1625.

At the time his death in 1626 John Bourchier was nearly bankrupt, and had various debts owed under complex legal agreements.

His soap business continued but on a very restricted scale. The patent was confirmed in 1631, and Bourchier's company was purchased for £5,000 by a new Company of Soapmakers of Westminster, patronized by the Earl of Portland (HMP, Bouchier, 2015). That Company was to make 5,000 tons of soap a year and pay the King £4 per ton. In return, its patent had the advantage of prohibiting both the export of tallow and ashes and also the import of potash into England (Price, 1906, 120).

The 'Soapers of Westminster' thereby obtained a monopoly for making white soap in 1631 (Conway, 2012, 184). A royal proclamation in 1632 that "*no oyle bee used in soap but olive and rape oyle*" severely disrupted the Muscovy Company's trade with Spitzbergen (Conway, 2012, 184). The Muscovy Company complained in 1634 that for the past eight years it had imported 1,100 tons of whale oil a year, all of which (except 50 tons) went into soap-making. The Westminster soapers then resumed use of the so-called 'train oil' (whale oil).

In 1631 Bouchier was given considerable prominence in '**Stow's Annales'**. He was named as having been the leading initial promoter of the alum industry of Yorkshire, in a short account published by the popular magazine '*Annales or A Generall Chronicle of England Begun by John Stow – Continued and Augmented by Edmund Howes* (London, 1631, pages 895, 898).

" In the 8 yeere of Queene Elizabeth, an Act of Parliament was made for confirmation of certain Letters Pattents granted two years before unto Cornelius de vos, a Merchant stranger for the sole making of Copperris and Allom within the Queens dominions for twenty one yeeres: as a reward for his new invention, thereby to encourage others to doe their endevours in the like actions, for the good of the common wealth, which Letters Pattents were set over unto James Lord Mountjoy, at whoss great cost the making of Copperris was then brought to good perfection; and then the making of Allom, after many attempts, was given over in Devonshire, where some small quantitie was made: also some was made in Ireland, and the like was attempted in Yorkshire, where there was a farre greater hope to prevayle therein: as indeed it did by the cost and industry of John Bouchier Esquire, who joined with the Lord Sheffield, then Lord President of the North, Sir Thomas Challenor, and Sir David Fowlis, and other having land in those parts, obtained Letters Pattents, from the Kings Majesty, for the sole making thereof, for thirty and one yeeres, and then they conieyned with certain Merchants of London, viz. William Turner, Nicholas Crispe, Ellis Crispe, and Abraham Chamberlaine, who used to lay the Allom Dirt, or earth, in the open ayre, and after putrefaction, to take the strength thereof, by the liquor, as it is used in making Salt Peter; which being found very changeable caused them to send into Germanie, where Allom had formerly beene made, from where they fetched certaine skilfull workemen, who taught them the true working by Calcination, which course they have followed.

And then in most space Mr John Boucher and his associates, brought their works into besired effect, to serve this kingdome which until now was served from the territorzies of Rome: whereupon the first of July, the king by Proclamation prohibited the bringing in of any Allom from beyond the seas, into any part of his Dominions, upon paine of confiscation : the king also obtained fit places or store-houses of Allom, for the ready use thereof, to such as would buy the same : the king gave also very gracious respect, and princely remuneration unto all those whom he knew to have taken paines, and been at expences in the practicing and atchiving to bring this royall commoditie unto due perfection, and then tooke the whole traffique thereof to himselfe"

The mistaken view that Bourchier was the first to introduce alum making into England in 1609 was repeated later by Sanders's '*Gesta Britannica'*, and '*Topography*' by Richard Gough (1735-1809) (volume 2, page 449), as George Young found when researching a history of Whitby in 1817 (Young, 1817, 2, 806; Gesta

Britannica, 1664). '*British Topography*' seems to have been Gough's 1798 English translation of Camden's '*Britannia*'.

(60 A) Charles Blount (7th Lord Mountjoy), Penelope Rich, and Mountjoy Blount.

Charles Blount (c.1562-1606) (TP M#438022), Earl of Devon, the litigant against Huntingdon over ownership of his father's alum-works in Dorset, was the second son of James Blount, 6th Lord Mountjoy, and Catherine nee Leigh. He had a distinguished military career and succeeded to the title as 7th Lord Mountjoy in 1594 after the earlier death of his elder brother William.

The politician Robert Naunton (c.1563-1635) produced a vivid, if biased, and not entirely accurate biography of Charles Blount in his book '***Fragmenta Regalia'* (1641**) (Naunton 1834, 119).

Charles studied at Oxford, but failed to get a degree, and then tried law studies at Clifford's Inn and Middle Temple. His elder brother William had been living in London, but William's career is undocumented.

At about the age of twenty Charles attended the royal court, where his youth and good looks quickly attracted the attention of Queen Elizabeth (1533-1603). He was "*brown haired, of a sweet face, and of a most neate composure"* according to Naunton.

While enquiries were being made across the room by the queen into his name, "*with the eye of majesty upon him as she was want to doe…his colour went and came, which the queen observing, called him, and gave him her hand to kiss, encouraging him with gracious words*" (Naunton, 1824, 132; Rickman, 2008, 115)). "*She said, faile you not to come to the court, and I will bethinke my selfe, how to do you good; and this was his inlet, and the beginning of his grace."*

Charles, "*being recently come to court…had the good fortune to run one day very well at tilt, and the queene was therewith so well pleased, that she sent him a token of her favour, a queene at chess, of gold richly enamelled".* He began to wear this on his arm, on a crimson band, seeing which the **Robert Deveraux (1565-1601), second Earl of Essex**, remarked that "*every fool must have a favour*".

In consequence, Blount challenged Essex to a duel in which Essex was slightly injured (Neale, 1967, 310). This led to a friendship between them (Naunton, 1824, 119). Deveraux had been a minor when his father died in 1576. His sisters went to live with the Earl of Huntingdon but, as a ward of the Crown, he like many similar young orphaned aristocrats became the responsibility of Cecil (DNB, 2004, 15, 945). Cecil ensured that he was well educated (Naunton, 1824, 114).

Deveraux was bookish, gaining an M.A. at Cambridge in 1581, before joining Huntingdon in York in 1582. In 1578 his mother Lettice Deveraux (1539-1576) secretly married the Earl of Leicester. In 1585 Robert Deveraux went with Leicester to the Netherlands as a colonel general of cavalry. He returned to London as a war hero in 1586, and became a favourite of the queen.

In 1585 Charles Blount accompanied the highly acclaimed commander Sir John Norris (c.1547-1597) on **campaign in the Low Countries**. "*There was in him an inclination to armes, with an humour of travelling, and gadding abroad*" (Naunton, 1824, 132). In 1586 he became MP for Bere Alston in Cornwall at a time, when 'election' to Parliament was in the gift of powerful, wealthy landowners.

He returned to the Low Countries in 1587, where he was knighted by the Earl of Leicester, but the Queen compelled him to return to England in October. He equipped a company of soldiers in the Low Countries, "*and would presse the queene with the pretences of visiting his company so often till at length he had a flat denyall*" (Naunton, 1824, 132).

Blount provided financial assistance towards building ships to oppose the **Spanish Armada**, and may have served on board one, possibly the 'Lion' or the 'Rainbow', or more probably onboard Drake's 'Revenge' (Sugden, 2006, 287). As a reward he was appointed Keeper of the New Forest in 1588. He received an MA at Oxford in 1589.

In 1593 he "*stole over with **Sir John Norris** into the action of Bretaigne, which was then a hot, and active war"* (Naunton, 1824, 132). "*Having twice or thrice stolen away into Brittany, where under Sir John*

Norris he had a company [of soldiers], *without the queene's leave and privitie; she sent a messenger…to see him sent home; and when he came into the queene's presence, she fell into a rind of rayling, demanding of him how he durst go over without her leave*…[and instructed] *see that you lodge in the court (which was then at White Hall), where you my follow your books, reade, and discourse on war*" (Naunton, 1824, 59). He continued to receive the salary of a Captain for the 1,000 men he had in Brittany. He looked upon John Norris like a father, and his "*deare friend, **Mr Secretary Cecill**, he adored as a saint".*

In 1594 he was appointed **Governor of Portsmouth**, a strategically important and vulnerable port at a time of continued Spanish ambitions. He renewed the fortifications of the port. During 1594 his older **brother William died**, and he became the eighth Lord Mountjoy. Because of "*the wane of his house*", his income even then was "*no more than a thousand marks per annum, wherewith he lived plentifully, in a fine garbe, without any great sustenance of the queene, during all her times*" (Naunton, 1824,132).

The queen forbad him from going on an expedition by Essex in 1696 to Cadiz, when the town was captured and burned (Williams, 1880, 137). He was allowed to go with Essex and Raleigh in 1597 to the Azores, as lieutenant of the land forces.

That expedition, to destroy a new Amada fleet and capture Spanish silver ships, went badly but the blame fell on Essex, not Mountjoy. At this stage he transferred his affiliation in court circles from the Essex faction to that of **Robert Cecil**, regarded by Naunton as "*this crooked politician*" (Naunton, 1924, 135). But Blount remained passive and was therefore overlooked in terms of preferment to offices of state.

In 1598 Mountjoy failed to be chosen as the Lord Lieutenant of Ireland leading a large new military force from England. Robert Deveraux, the second Earl of Essex, was appointed instead. Paradoxically this increased their friendship.

According to Naunton, Blount sent a message in 1599 to Scotland on behalf of Essex, to inform King James that Essex supported his right to the English succession. In Ireland, Essex reached an unauthorized truce with Hugh O'Neill, Earl of Tyrone. There was possibly even an agreement of help for Essex in ousting the queen, and Elizabeth compelled him to return and remain in London (Neale 1967, 367).

In 1600 Blount was appointed **Lord Deputy of Ireland**. In Naunton's account, Essex tried to persuade Blount to use the new army assembled in London to treacherously arrest Elizabeth's councillors, but he departed without doing so. He was supposed to establish garrisons at Loch Foyle and Ballyshannon, and to revitalize the English army opposing the rebels. Blount took a very cautious approach, minimizing losses while enforcing a ruthless burnt-earth policy.

It is now known that both Charles Blount and Essex's sister Penelope were both deeply implicated in the plots of Essex (Neale, 1967, 374). Mountjoy wrote from Ireland to James IV of Scotland assuring him that if a Scottish army was mobilized, he would provide 5,000 troops from Ireland to put Essex in power and declare James the heir to the throne.

In April 1660 Essex sent his long time associate and co-conspirator **Henry Wriothesley** (1573-1624), the third Earl of Southampton, to Ireland with a letter requesting Blount to invade through Wales, but he refused. During September, Elizabeth refused to renew Essex's contract to 'farm' the customs on sweet wine imports. This was his main income. Already deeply in debt, he was increasingly desperate.

In February 1661 five of the **conspirators met at Southampton's lodgings** in London, without Essex to reduce suspicion. They made impractical plans to seize the Court, Tower of London, and the Queen.

Eventually the Council summoned Essex to attend and explain himself. He refused. The **attempted coup** began with a disorderly, poorly armed rabble of two hundred young nobles and gentlemen being led by Essex, Southampton, and the catholic Sir Christopher Blount (1556/6-1601) from Kidderminster who was unrelated to Charles Blount. Christopher had served in Robert Dudley's household, and later married the widow Lettice Knollys, who was the mother of Essex.

The traitors expected to be greeted by a popular uprising, but were disappointed. They were turned back at Ludgate by loyal militia organised by Robert Cecil. The ringleaders were soon caught and imprisoned. Christopher Blount was executed. The queen was persuaded by Robert Cecil to spare the life of Salisbury.

Essex was arrested for treason, and before his execution volunteered a full confession, implicating both the absent Charles Blount and his own sister Penelope Rich (Neale, 1967, 381). Charles considered fleeing from Ireland to France, but did not. His successful policy in Ireland dissuaded Elizabeth from pursuing him for his connection with Essex.

When 3,400 Spanish troops seized Kinsale, the Earl of Tyrone with 6,500 men abandoned their well defended position in Ulster to link up with the invasion. At Kinsale, **Blount's cavalry intercepted Tyrone** who received no assistance from the Spanish. After this English victory, the Spanish withdrew and eventually the rebellion was suppressed. The Earl of Tyrone surrendered to Blount, who took him to London.

James I had just ascended the English throne. He made Blount **Lord Lieutenant of Ireland**, and a Privy Councillor in 1603. Blount remained in England, received substantial grants of land both there and in Ireland, and was created Earl of Devon. In 1605 he presided over the **investigation of the Gunpowder Plot**. He also patronised poets.

Charles Blount had three illegitimate sons with **Lady Penelope Rich** (**1563-1607),** who had been his lover since at least 1590 (DNB, 2004, 6, 305).

Penelope (TP F#67849) was the eldest **daughter of Walter Dervereux, first Earl of Essex**. Before his death he had wished her to marry the dashing poet and courtier Sir Philip Sidney (1554-1586) (Rickman, 2008, 113).

Her new **guardian, Henry Hastings (1536-1595), Earl of Huntingdon**, compelled her instead to marry the wealthy Robert Rich (1559-1618/19) (TP M#67848) first Earl of Warwick, in 1581. After the marriage Sidney still wrote sonnets representing Penelope.

Charles Blount would have known Penelope well through his association with her brother Essex. Charles had his own grievances against Henry Hastings regarding the alum business developed by his father James Blount in Dorset.

A number of modern authors have reviewed the life of Penelope (Rickman, 2008, 114). With Robert Earl of Warwick, she had two sons, Robert and Henry, and two daughters Lettice and Essex.

Lord Rich obtained a divorce in the ecclesiastical courts in November 1605, on the grounds of Penelope's adultery with Blount. The divorce specifically forbad remarriage during the lifetime of each spouse. Robert did not remarry until 1618, to Frances Wray.

Charles and Penelope married in 1605, contrary to canon law, in a ceremony conducted by his **chaplain William Laud (1573-1645)** (Naunton, 1824, 134). Laud had been Charles' chaplain since 1603, and later implausibly claimed ignorance of Robert Rich being still alive.

Laud was the son of a Reading clothier, and rose to become Archbishop of Canterbury in 1633 (DNB 2004, 32, 655; Williams, 1980, 254). He enjoyed the patronage of George Villiers, first Duke of Buckingham, and later of Thomas Wentworth, Earl of Strafford.

His 'high church' authoritarian policy, and enforced sensorship, gradually became viewed as sinister. Wentworth opposed Puritanism, and Laud opposed Calvanism, at a time when the Counter-Reformation was growing in Europe. Laud was imprisoned by the Long Parliament in 1640, and executed in 1641 despite receiving a royal pardon.

Parliamentary revision of the marriage laws had specifically omitted making a marriage like that of Blount a felony, and **James I treated Penelope generously**. He restored her to the rank of her ancestral Earl, and appointed her as a Lady of the Bedchamber (Orgel, 1996, 131) But their children were still considered illegitimate, and Blount's titles were extinguished with his death. This was in 1606, from respiratory disease, probably caused by his tobacco smoking habit. His wealth then was about £20,000, allowing a generous inheritance to Penelope and to his eldest son **Mountjoy Blount (c.1597-1666).**

Mountjoy Blount in 1628 became the first Earl of Newport on the Isle of Wight (DNB, 2004, 10, 305). His name was used for the 'knight' or small artillery bastion built onto the southeast tower of Carisbrooke Castle in 1587 and then for the tower itself (Young, 2000, 27, 28, 68). It was also applied to the nearby hill

Mount Joy (Kokeritz, 1940, 103). Mountjoy Blount was half brother to Henry Rich (c1590-1649) first Earl of Holland, and Robert Rich (1587-1658), second Earl of Warwick.

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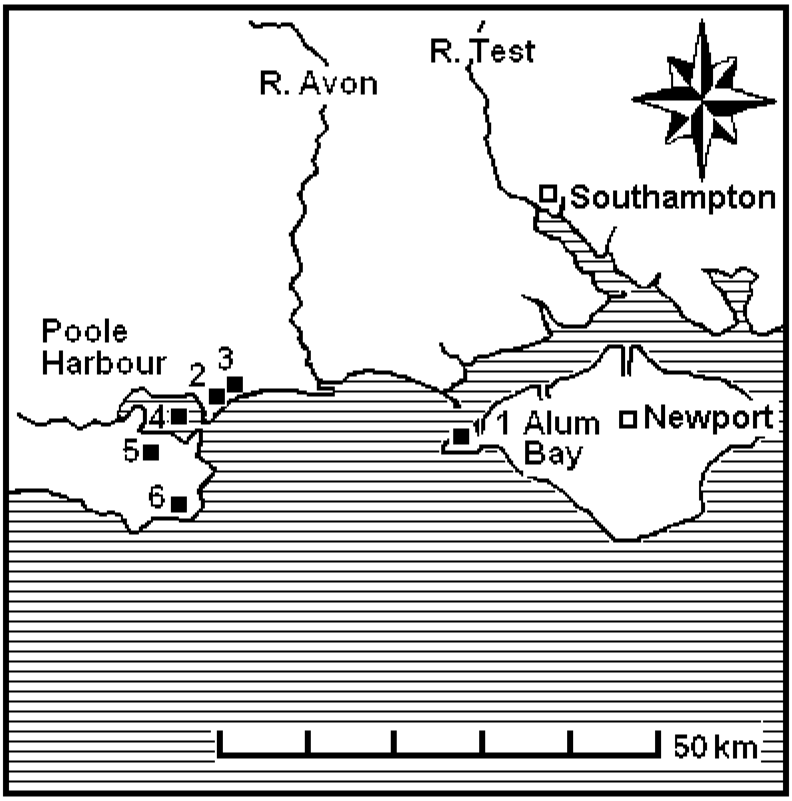
South Coast Alum and Copperas Locations.

1. Alum Bay, Isle of Wight 2. Canford 3. Boscombe
4. Brownsea Island 5. Smedmore 6. Kimmeridge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