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The Floating Egg

Roger Osborne

About the Author

Roger Osborne studied geology at Manchester University in the early 1970s. He then worked as a publisher of scientific, medical and technical books before becoming a full-time writer in 1992. He is the co-author of *The Atlas of Earth History* and *The Atlas of Evolution*, and lives in North Yorkshire.

THE FLOATING EGG

Episodes in the Making of Geology

Roger Osborne

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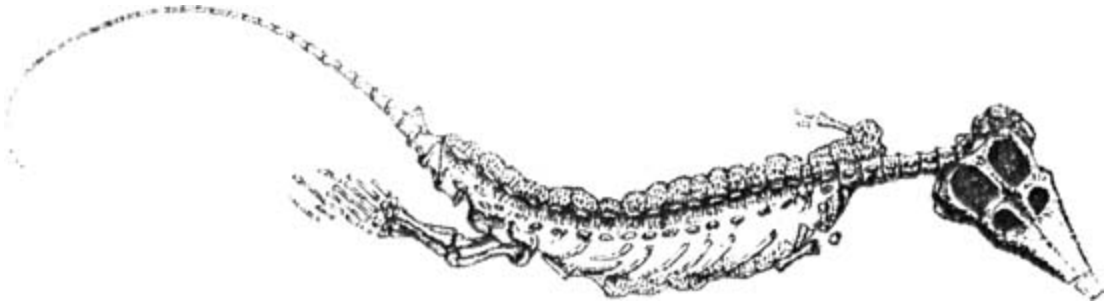

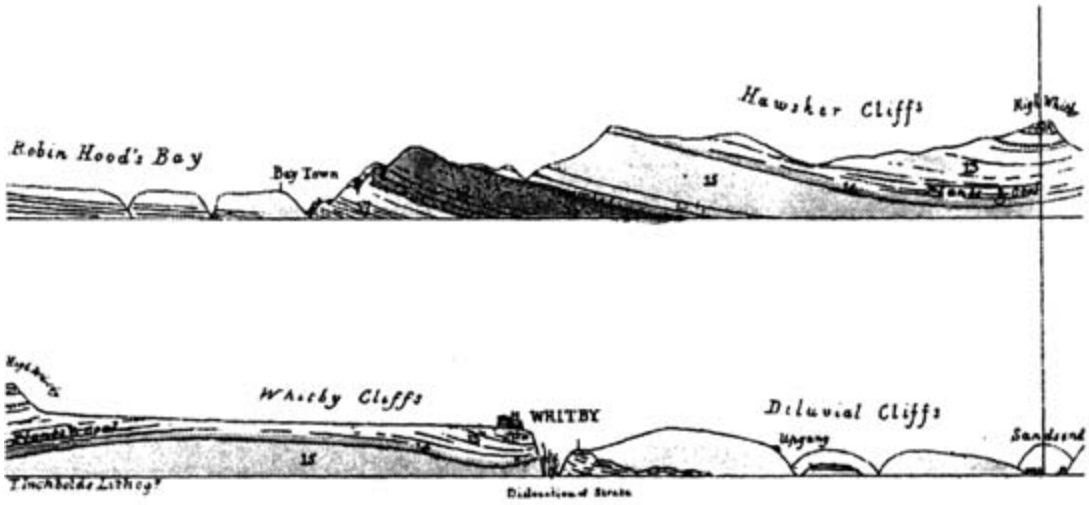

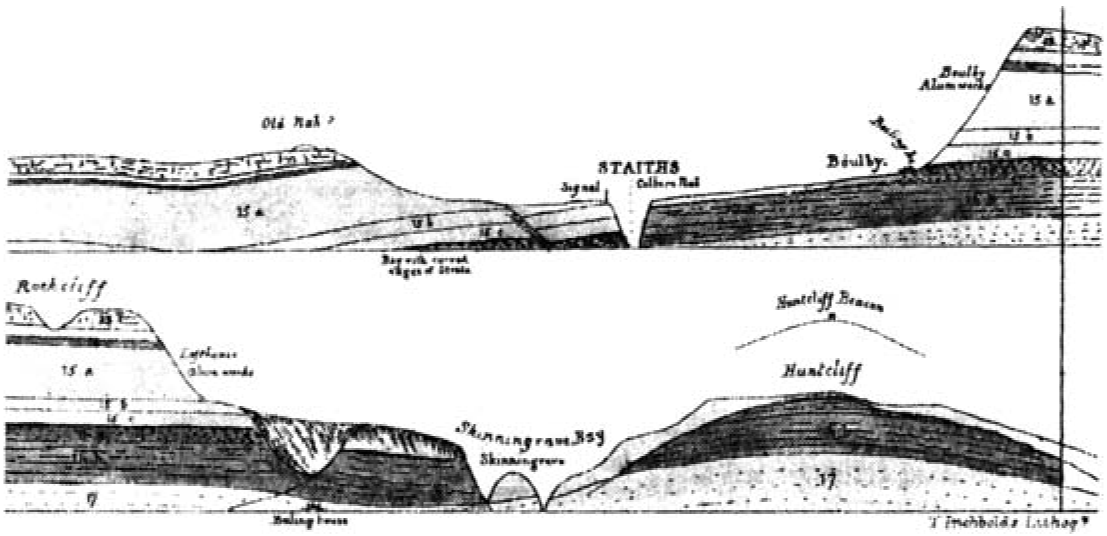
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The setting for the episodes related in this book (taken from Illustrations of the Geology of Yorkshire *by John Phillips, 1829*).

Preface

In the next few hundred pages all is not quite as it seems. The pieces of writing that follow are all concerned with the origin and development of geological sciences in a particular part of the world (see the map opposite). Each piece is a separate story, and the reason for their coexistence will become apparent as they are read. The stories are arranged in approximate chronological order of the events they describe, though the ‘reptile tales’ follow a separate order from the other pieces. Having made that rule for the organisation of the book, I then broke it several times in order to make the whole thing somehow more agreeable. Let us just say that the main pieces begin with the alum trade in the early seventeenth century and end with the discovery of ice-age lakes in the early twentieth. There is also a brief chronology of events at the back of the book.

Some confusion might arise over the authorship of these stories, and the reality or otherwise of the events they describe. So let me begin by asserting that everything in this book is true. All of the events described took place, most of them ‘exactly’ as documented. Every document that is quoted from is real, and is listed in the Notes and Sources. In those pieces where the author is a real ‘other’ person, his or her name and full reference is given. Those pieces which are written by me as a factual historical narrative will be obvious to the reader. In only three longer pieces is the narrative or the narrator in any way fictional, as follows.

In ‘A Journey to a Birth’ the narrator is Samborn Palmer. He is a real historical figure who accompanied William Smith on the journey which the story relates. The story is ‘fictional’ but the events are as described by William Smith to his

nephew John Phillips, who then wrote them down (Smith was a practical man who was averse to writing). ‘The Strange Case of the Hyenas’ Bones’ is narrated by a fictional character of my own invention, John Foster. Apart from Foster and Dawson, the other characters and the principal events in this story are as described in William Buckland’s own works, and by subsequent historians of geology. In “From under the ice’ the narrator is fictional, as is the story, and really needs no further explanation.

All of the stories in this book draw heavily on the work of other authors, some to the point where they are simple reproductions of what others have written. Because of this intimate relationship between the content of the stories and the primary source material, I have included a full chapter-by-chapter list of sources, and in some cases further explanations of individual chapters, at the end of the book. There are, though, some individuals whose help has been so important in the conception and writing of this book that they should be listed here. I therefore unreservedly thank Mike Benton of the University of Bristol for his initial encouragement and for the information he provided; Christopher Toland for sharing his enthusiasm for, and knowledge of, the history of geology in Yorkshire; and most of all my editor Will Sulkin, whose nurturing of this book and its author has been above and beyond the line of duty. In addition Messrs R. L. P. and J. G. Pickles of the Whitby Literary and Philosophical Society, together with the staff of their museum and library have been of great help, as have the staff of the libraries of the Geological Society and the Royal Society. They have my sincere thanks.

Roger Osborne
Scarborough, 1998

chapter one

Dangerous Rocks

‘The most singular accident’

“The coast from Saltburn to Scarborough, and even to Bridlington Quay, is generally high and bold, except in the bays and inlets. At Huntcliff, Rockcliff, Kettleness, Peak, and a few other places, the cliffs are lofty, and in some parts precipitous. Hence these shores are not only dangerous to mariners in stormy weather, but cause many fatal accidents to others who frequent them. The most singular accident that ever happened on the coast, occurred about 15 years ago, under the high cliffs a little to the west of Staiths. While two girls of the name Grundy, belonging to Staiths, were sitting on the *scar*, or rocky beach, with their backs to the cliff, a splinter, which by striking against a ledge had acquired a rotatory motion, fell from the cliff, and hitting one of the girls on the hinder part of the neck, severed her head from her body in a moment, and the head rolled to a considerable distance along the scar.”

George Young, 1817

chapter two

But Dreames

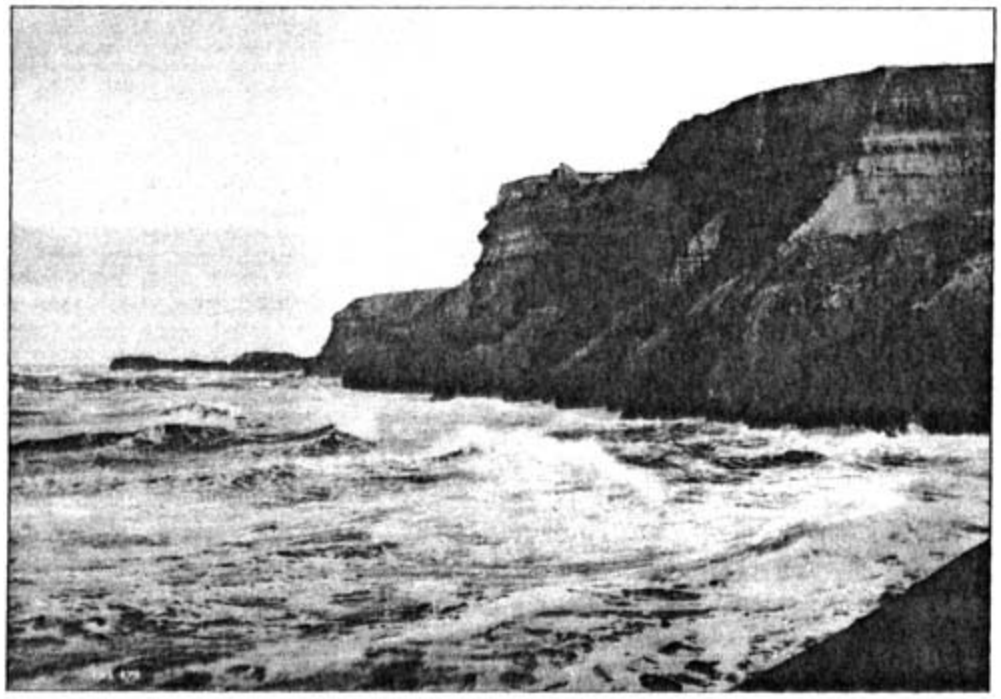
In search of the alum-maker's secret

> "The World hath beene much abused by the opinion of *Making of Gold*: The Worke it selfe I judge to be possible; but the Meanes (hitherto propounded) to effect it, are, in the Practice, full of Errour and Imposture; and in the Theory, full of unfound Imaginations. For to say, that *Nature* hath an Intention to make all Metals *Gold*. And that, if she were delivered from impediments, shee would performe her owne Worke; And that, if the Crudities, Impurities, and Leprosities of *Metalls* were cured, they would become *Gold;* And that a little *Quantity* of the *Medicine*, in the Worke of *Projection*, will turne a Sea of the *Baser Metall* into *Gold*, by *Multiplying*; All these are but dreames."
>
> Francis Bacon, 1626

The etymology of 'alchemy' is instructive and deceptive. The origins of the word lead us into the market-places and academies and the secret places of the eastern Mediterranean, where Greek apothecaries learned from Egyptian travellers, and Arab physics made practice from the natural philosophies of scholars. Alchemy is defined by us, in a striking piece of historicism, as 'the infant stage of chemistry'.*1 All are agreed that its origin *is* the Arabic word *al-kimya*. But the origin of *kimya* is disputed, though it is probably Greek. The Greek language has several similar words. *Khemia*, which means 'black land', was the name given to Egypt by the Greeks, according to Plutarch. They were following the Egyptians who called their own land

Kemi, the black land. Khemia is then possibly ‘the Egyptian art’ or it may mean the ‘black art’ or ‘dark practices’. Another Greek word *khymeia* means fusion, perhaps the combining of precious metals. Then there is *Chymes*, who has been suggested as the inventor of alchemy. And finally the word *chyma* which means fluid, or the art of pouring.

But the principles of alchemy – the freeing both of substances and humans from their corrupt temporal existence, into the eternal purity of gold and immortality – are older than the word. Records of these in India and China are as ancient as written language.



Cliffs east of Whitby. The cliffs of the Yorkshire coast were transformed from base rock into apparently limitless riches.

FRAGMENTS TOWARDS A HISTORY OF ALUM

> “Not less important, or indeed dissimilar, are the uses made of *alumen*; by which name is understood a sort of salty earth . . . the white alumen being employed in

a liquid state for dyeing wool bright colours, and the dark-coloured alumen, on the other hand, for giving wool a sombre tint. Gold is purified with black alumen. Every kind of alumen is from a limus water which exudes from the earth. The collection of it commences in winter, and it is dried by the summer sun. That portion which first matures is the whitest. It is obtained in Spain, Egypt, Armenia, Macedonia, Pontus, Africa and the islands of Sardinia, Melos, Lepari, and Strongyle; the most esteemed, however, is that of Egypt, the next best from Melos."

Pliny (23–79 AD)

"Alum (*fan shih*)

It comes now from Hsi-chhuan [Szechuan] in the north of I-chou, crossing the (Yellow) River from the west. Its colour is greenish-white. The crude stuff is called 'horse-tooth alum', but after purifying it becomes very white. People in Szechuan often mistake it for nitre (*hsiao shih*), but it is white alum . . . The Manuals of the Immortals say that it can be taken by itself, and it is used also in elixir formulae. After being ground in water it can be combined with plant drugs, then boiled and heated to dryness; it is good for toothache but spoils the teeth if used in excess. This shows that it is injurious for bones, so I doubt the statement that it hardens bones and teeth."

Thao Hung-Ching (456–536 AD)

"Methods for preparing the elixir of life, which are known to be wrong or dangerous, but which are popular among the people.

- Boiling the ash obtained from burning mulberry wood.
- Mixing common salt, ammonium chloride and urine and evaporating to dryness.
- Digesting saltpetre and quartz for a long time in a gourd and using the product.
- Boiling saltpetre and blue-green rock salt in water.
- Making an egg-shaped container of silver to hold cinnabar, mercury and alum.
- Using iron rust and copper as ingredients for an elixir called ‘golden flower’.
- Heating mercury together with malachite and azurite.
- Heating realgar and orpient.
- Heating black lead with silver.
- Burning together dried dung and wax.

Some alchemists have heated sulphur together with realgar, saltpetre and honey, with the result that their hands and faces have been scorched, and even their houses burnt down.”

Chen Yuan Miao Tao Yao Lueh (Classified Essential of the Mysterious Tao of the True Origin (*of Things*)) (8th or 9th century)

“The Nature of Alum

Alum is an oil which has been coagulated by the dryness of the earth, and there are many mines of it. The son of Gigil of Cordoba said that Gigil had a mine to the north of Cordoba in a place which is called Neeris, in the neighbourhood of old Cordoba.

And there is in its nature heat and dampness; and it is called lime and *sicum*. And indeed it retains every volatile spirit and it cleanses metals with a good cleaning and embellishes them, and increases their

dyeing. Nevertheless it dyes a white thing black as long as it is not made active from the nature of the white thing, and it is not destroyed; and it makes a white thing red as long as it dyes them with a good natural redness, and it remains dyed for ever . . .

“The Method of Jamen Alum

The method of using it is, that you take some pure white woolly Jamen alum, and pound it very well, and put it in a glass jar; and you pour over it four times as much boys’ urine. After boiling them down and depending on the age of the urine, boil it over a small flame with the alum, and stir it well with wood, and set it aside until the sediment of it settles down on the bottom. Then filter it gently and put aside the urine with your collection of secrets.”

Rhazes (Abu Bakr Muhammad al Razi), (10th century)

“A hundred years of living is as a spark from a stone, and the course of life a bubble floating on water. Those who think only of profits and emoluments, seeking worldly prosperity and glory, will soon find their faces turning pale and their bodies withering. Even if they have piled up riches mountain-high, may I be allowed to ask whether they can buy off the Messenger of Death . . .

Compound not the three yellow substances (sulphur, orpiment and realgar), neither the four magical things, (alum, cinnabar, lead and mercury); and make no search for particular plants (as elixir ingredients) for they are still further from the genuine (medicine).”

Chang Po-Tuan, (d. 1082), *Wu Chen Phien* (‘Poetical Essay on Realising the Necessity of Regenerating the Primary Vitalities’)

“[alum (*fan shih*)] can turn iron into copper . . . The yellow and dark yellow sorts of alum are called ‘bird-droppings alum’; these are not used in pharmacy but are only suitable for the plating (*tu*) (of metals). When they are added to processed copper (*shu thung*) (powder), being made into a paste with crude vinegar and smeared on the surface of iron, the iron is all turned to the colour of copper. But although the outside colour becomes coppery the material inside remains quite unchanged.”

Ching-Shih Cheng Lei Pei-Chi Pen Tshoa (the Classified and Consolidated Armamentarium of Pharmaceutical Natural History) (1083)

MINERALS AND SECRETS

How would we know the alum-maker’s secret? This, at least, we can answer – it is now written down, freely available, much wondered at; and entirely useless. Overtaken by history, it has served its time, and in its time it possessed the power to turn the basest rock into a substance worth more in the world than gold itself.

The source of alum is almost everywhere, in almost every rock. It is the knowledge of its manufacture that is wanted. We meet alum frequently enough in the pages of history – a magical element in Chinese and Arabic alchemy, a reagent in early chemistry, a mordant and tanning agent, a medicine, an essential part of the agricultural manufactories of early modern Europe – a chemical that every flexing, strutting state needed to give substance to its virility.

The name of this substance means little to us now. Our society is disaggregated enough for us to live well without knowing much of what enables us to do so. Alum is still a vital chemical in every developing and industrial society. But the problem of obtaining alum has been solved, and so the substance has disappeared from view. Invaluable yet invisible, it is the concern of just a few industrial chemists.

To our predecessors the opposite was true. Alum was essential, and scarce. It was therefore a strategic commodity, and a potential source of vast wealth and political influence. Anyone who knew how to make alum, who found how to transform stone into wealth, who had the alum-maker's secret, might hold half the world to ransom.

But can history – by which we mean the written record of the past – bring us face to face with the origins of something which was never, being secret, transcribed while it was of value; something that could only emerge into view once chemistry caught up with alchemy, and the keeping of secrets was replaced by the sharing of knowledge; when science began to understand technology?

THE 'HOLY FATHER'S MARCHANDISE'

At some time in the early decades of the fifteenth century John de Castro, an Italian whose origins are unknown, set up a cloth dyeing factory in Constantinople. Venice, Genoa, the Papacy and other city states of Italy traded in manufactured goods and raw materials, including alum, with the cities of the region we now call Asia Minor. Italians moved east and set up as traders, shippers and manufacturers. John de Castro used alum as a dye fixative in his work, he knew its value, and he learned something of how it was made. It is thought that Italians were involved in alum manufacture near the port of Smyrna (now called Izmir), but their names are unknown.

The area around Constantinople was the remnant of the Byzantine lands, while the cities of the eastern Mediterranean and Persia were ruled by families whose influence spread only a little further than their own city walls. Vast areas of countryside were controlled by nomadic tribes. In a process endlessly repeated in the history of human affairs, a unifier emerged to persuade the nomads of the outer lands of their sufferings, and to lead them against the cities of the centre. The leader was called ‘Uthman, which in Turkish is Osman, and this is represented in English as Ottoman.

The power of the Ottomans originated in Anatolia and spread west into south-eastern Europe, and eventually east and south into Syria, Egypt and western Arabia. By the middle of the fifteenth century the city of Constantinople with its vigorous mix of Islamic, Christian, Arabic, Byzantine and European peoples, was isolated. In 1453, one of the most symbolic dates in the intertwined histories of Europe and Asia, an event both unimaginable and inevitable happened – Constantinople fell to the Ottoman armies of Mehemmed II. The illusion of the Holy Roman Empire in the East was, at last, dissolved. John de Castro, together with most other Europeans, left Constantinople. He was able to return to Italy and gain employment under the Apostolic Chamber, part of the administration of the Papacy – spiritual ruler of Christendom and secular ruler of central Italy.

The Ottoman Empire now controlled Europe’s alum supply. The textile manufactories of Italy needed alum, so they bought it from the Turks. But they hated their dependence on this troublesome, expansive, unchristian power, and desperately sought their own supply. A few small works were started, more in hope than knowledge, and these foundered.

John de Castro began his own investigations in the area around Rome. The Tolfa hills, north-west of the Holy City, had been a source of minerals from the times of the

Etruscans, twenty centuries earlier. De Castro found rock at Tolfa which looked the same as those he had seen being worked for alum near Constantinople and Smyrna. He made tests, which convinced him that he was right. ‘Experts’ were sent from Rome, who, it is said, ‘shed tears of joy, kneeling down three times, worshipped God and praised His kindness in conferring such a gift on their age.’ The works at Tolfa, not sixty miles from the Vatican itself, were established as a Papal monopoly, and were producing alum by the year 1459 – a mere six years after the fall of Constantinople. It was, in the view of Christian Europe, a victory for God over the infidel.

There was enough alum in the Tolfa hills to supply the whole of Europe for a hundred years. Alum might have carried on bringing gold to the Pope’s coffers for hundreds of years to come, had not the Church encountered its own difficulties. Europe’s only source of alum belonged to God’s sole representative on Earth. As one monopoly unravelled, so did the other.

In 1517 it was decided that the Church of St Peter in Rome was in need of rebuilding and repair. Notices were sent out to the cardinals and archbishops of all the countries of Christendom, that money should be raised from their flocks, so that the parish church of the Catholic faith should be made glorious again. So the Archbishop of Mainz, a historic city on the banks of the Rhine, dispatched a Dominican friar by the name of Tetzel to the town of Wittenberg. There he was to sell indulgences, so that the faithful might buy remission from the punishment of their sins, and help the Church on Earth at the same time. We know only enough of Tetzel to say that he took his proper place in a story that was necessarily beyond his comprehension.

It was another story of the type that appeals to our misguided sense of the potential of every man to shake the world. A figure of impregnable authority, carrying the force

of the spiritual and secular world in his person, approaches the moral and geographic milieu of a slightly troublesome yet impotent irritant – and is brushed aside by . . . what? The requirements of history? By the needs of a widely diffused force of dissent to find a single point of expression? Or by the moral authority of one unexceptional, exceptional man: Martin Luther.

Six years before Tetzel's arrival in the town where he taught and preached, Luther had made his pilgrimage to Rome, where he had been overwhelmed and sickened by the luxury, wealth and power games that were the daily life of the Papal court. He returned to the Germanic states and preached a doctrine of grace and faith based on his readings of St Paul and St Augustine. In particular he spoke against the sale of indulgences.

The arrival of Tetzel forced Martin Luther to carry his arguments further. As every European schoolchild is now taught, he drew up a list of forty-nine arguments, or *theses,* against the sale of indulgences and nailed it to the door of Wittenberg church. Within forty years Protestantism in one form or another was established in the major states of northern Europe, under the doctrine of Augsburg – *cujus regio, ejus religio*, the religion of the ruler is the religion of the state.

The dependence of the cloth and leather industries of the whole continent on one supplier of alum was unstable before the Reformation. Afterwards it was impossible. In 1536 a German physician named Georg Bauer, who, in the fashion of the times gave himself a 'Latinised' name, Georgius Agricola, published a book entitled *De Re Metallica*. Further editions of the book appeared in 1561, 1621 and 1657. It was the first attempt to produce a systematic guide to the production and properties of different metals and minerals, and included details of three different methods of producing alum. Though Agricola was able to outline the process, he did not mention the alum-

maker’s secret, without which the process is unworkable. He may have considered it unimportant, or he may not have known of its existence. He might have known about it, but been unable to discover what it was. The secret remained.

The bringing of alum-working to the cliffs of Yorkshire, which was the first and only source of alum in Britain from 1600 until 1870, is documented, but not detailed. So relatively late in history our vision is clouded by a perplexing mix of romance, prejudice, myth-making, and the aggrandisement of important men. It seems that the growth of printed matter can be a false guide to the paths of history – not all writers felt the need to record what was true. To their unreliable bequests we can add our own ‘knowledge’ of documentation and of scientific laws – these, at least, have little variance with time.

By the late sixteenth century there were alum works in Germany and Flanders, but none in the British Isles. England, its commerce expanding, its alliances fractious, was desperate for a dependable source of its own. (Later reports that Henry VIII married Anne of Cleves to get access to the Flanders alum are an exaggeration, not an impossibility.) A licence granted in 1560 to a W. Kendall to manufacture alum from rocks in Devon and Cornwall is a sign of activity and of ignorance. There is no rock in these counties from which alum could practicably be made, as a rudimentary knowledge of Agricola’s work would have shown.

The first document that betrays the anxieties of the English court is a Letter Patent granted by Elizabeth I in 1565.

> “Elizabeth, by the Grace of God, Queen of England, France, and Ireland, Defender of the Faith &c. To all Men to whom these Letters Patent shall come, Greeting. Where heretofore we have granted Privileges to Cornelius de Voz, for the Mining and

> Digging in our Realm of England, for Allom and Copperas, and for divers Ewers of Metals that were to be found in digging for the said Allom and Copperas, incidentally and consequently without fraud or guile, as by the same our Privilege may appear."

This 'licence' stimulated some attempts – Alum Bay on the Isle of Wight is named for a fruitless sixteenth-century quest – but prospectors clearly had no idea what they were looking for.

We next come upon alum in John Aubrey's *Lives of Eminent Men*, written in the seventeenth century, but unpublished until the nineteenth. Aubrey writes well of a North Country gentleman, Sir Thomas Chaloner, who was known enough to be appointed tutor to Prince Henry, eldest son of King James. Aubrey approves of his subject.

> "He was a well-bred gentleman, and of very good naturall parts, and of an agreable humor. He had the accomplishments of studies at home, and travells in France, Italie, and Germanie . . . He was as far from a puritan as the East from the West."

So far, so good. But now Aubrey ventures into the territory of the technical. Chaloner was, he writes,

> "riding a hunting in Yorkeshire (where the allum workes now are), on a common, he tooke notice of the soyle and herbage and tasted the water, and found it to be like that where he had seen the allum-workes in Germanie. Whereupon he gott a patent from the King (Charles I) for an allum worke (which was the first that ever was in England), which was worth to him two thousand pounds a year or better: but tempore Caroli I some courtiers did thinke the profitt too much for him,

> and prevailed so with the king, that, notwithstanding the patent aforesayd, he graunted a moetie, or more to another (a courtier), which was the reason that made Mr Chaloner so interest himself for the Parliament-cause, and, in revenge, to be one of the king's judges."

Allowing for technical inaccuracies, we need look no further than this passage for the intertwining of commerce, politics and the riches of the earth – and of the penalties for misjudgements in any of these. The patent was, in fact, granted to Chaloner by James I (or even Elizabeth), who used this method for raising money without the inconvenience of assembling Parliament – a habit that was to cost James's son his kingdom and his life. Maybe Aubrey is seeking a simple reason for a complex matter – why should an English gentleman landowner turn into the ardent republican that Chaloner became, even to the point of sitting in fatal judgment on his own king? But if King Charles treated Chaloner unjustly, or gave him cause to think so, and if he behaved similarly to others, he paid the ultimate price for his divine exercise of power.

Chaloner, an energetic, ambitious scholar-merchant, is our bridge between the old southern, Catholic-dominated, Romish Europe with its debts to scholasticism and classical Rome; and the new, northern, Protestant or even atheistic world, owing intellectual allegiance to Platonic Greece, and to its own self-confident rationalism. But Chaloner has enough of the old world to be cloaked in a swirl of romance. It was Chaloner, it seems, who brought the alum-maker's secret to England.

The managers of the Papal alum works at Tolfa were well aware of the value of the secret they held – the secret of

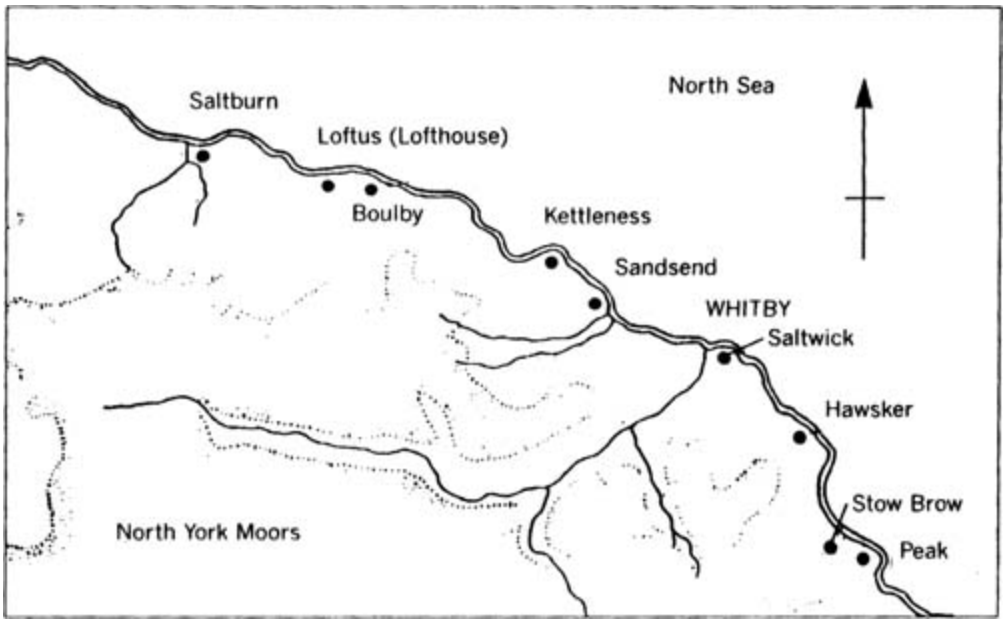
turning common rock into precious alum. Why else were the workmen kept in virtual captivity? To protect the great secret was to protect the wealth of the Papacy.

On a tour of Europe, during which he saw mineral workings in Germany and Italy, Sir Thomas Chaloner sailed into the harbour of Civitavecchia, the alum port of the Papal states. It is said that he visited the alum works, though whether he was permitted to see everything at close hand is doubtful. Whatever he did see persuaded him that he needed to know what was going on inside the alum houses. He therefore did the simplest, and most dangerous thing – he persuaded one, or perhaps two, of the Italian workmen to abscond with him. The legend says that he smuggled them on to his ship, anchored at Civitavecchia, in a barrel, and sailed for England before they were missed. George Young, writing in 1817, says the men were called Russel, which must have been an Anglicisation of their Italian names.

Now Chaloner had the alum-workers, but did he have the alum-workers's secret? It is said that, for his crime, Chaloner was excommunicated. Though there is no specific evidence of this, we can judge the likelihood by this passage from Bishop Latimer's sermons (1596); alum was, we need not doubt, a precious and holy matter:

> "I heard a great while ago a tale of one. He hath travelled in mo countries than one. He tolde that there was once a Pretor in Rome, Lord major in Rome, a rich man, one of the richest marchants in all the Citie, and suddenlie he was cast into the castell Angell. It was heard of, and everie man whispered in anothers eare. What hath he done? hath he killed any man? No. Hath he medled with Alam, our holy fathers marchandise? No. Hath he counterfeited our holy fathers Buls? No. For these were hie treasons. One rounded another in the eare and said: *Erat dives*, he was a rich man. A great fault."

Chaloner must have known, or been told, that his shales had potential for the manufacture of alum. Agricola's *De Re Metallica* was available to diligent scholars, and its contents would have reached England by the late sixteenth century.*2 Even with this knowledge and the expertise of his Italian workmen, it took several years for the works at Belman Bank to produce pure alum. Once they did, the value of the alum shales was an open secret.



Sites of alum works on the Yorkshire coast over nearly three centuries (after Marshall, 1995)

The shales occur in a band up to 35 metres thick in the Lower Jurassic, Toarcian section of north-east Yorkshire. They outcrop inland in a few places, as at Belman Bank. But their greatest exposure is on the series of towering cliffs that run from Loftus in the north-west, through Boulby, Port Mulgrave, Kettleness and Sandsend to Whitby; and then on through Saltwick, Hawsker and Robin Hood's Bay to Blea Wyke in the south-east. Every landowner whose estate encompassed a portion of that desolate, beautiful, useless

coastline, was instantly an industrial baron. Chaloner and his heirs had no monopoly on the outcrops of alum shale, nor on the alum-maker's secret. It was impossible to contain knowledge at such close quarters. The secret spread along the coast, and so did the alum works. In the two and a half centuries from 1620 to 1870, the cliffs were ripped open and thrown on to the beach. Millions and millions of tons of rock were taken out by pickaxe and wheelbarrow. By the early part of the nineteenth century production was over 3,000 tons of alum per year. Twelve tons of shale produce one ton of alum. At least three tons of overburden would have been removed for every one ton of shale. The pretty seaside town of Sandsend was built solely for alum workers. And even the famous port of Whitby owes more than it will admit to this first industrial-scale chemical technology. Historians will glibly say that Whitby is an ancient fishing port, prospering and expanding with its fisher fleet and through shipbuilding. But until the alum trade came, hungry for coal and wanting a harbour to ship out its precious mineral, Whitby was a fishing village with a ruined abbey incongruously attached, not a port.

Alum is a double sulphate – aluminium and either potassium or ammonia form the positive ion, sulphate the negative. The two most common elements in the Earth's crust are aluminium and silicon; almost all rock-forming minerals (olivines, amphiboles, pyroxenes) are aluminosilicates. These are extremely stable structures. The task of the alum-worker is to break down the common aluminosilicates in the presence of sulphur, in a way that allows the aluminium to be freed to form a sulphate. In order to enable this to happen an alum source must have three crucial ingredients, apart from the aluminosilicates that occur in every rock; it must contain sulphur (usually as iron pyrite), water and