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Alchemy for beginners: social concepts surrounding the artisanal-scale smelting of ochre obtained from mine water treatment

Aidan Doyle and Jonathan Aumônier

Abstract

Modern scientific chemistry has obscure roots in the dark discipline of alchemy, in which mysticism and practical scientific enquiry were long conflated. Alchemists attempted to configure practical metallurgical observations with philosophical and epistemological speculations into the nature of substances. The underlying tenet of the alchemist was the possibility that through understanding the nature of substances these substances could be changed: from a base to a noble state for instance. A similar change of 'nature' is arguably relevant to the issue of ochre re-use: we can address the problem of worthless materials despoiling the landscape after industrial activity by reconfiguring conceptions of their worth, for instance by taking ochre derived from mine water treatment and producing useable iron.

To put our practical smelting of ochre into context, this paper traverses discourses on several themes, including branches of the social sciences together with history and 'crypto-history'. It investigates geographical perspectives in which the key issues are the interaction of local society with its environment, the interdependence of local and global societies, and (leading from these) the recognition of local cultural differences. A brief summary of the alternative histories of ironmaking is presented to highlight the tensions between 'history' and 'heritage'. Through the practical application of 'primitive' ironmaking techniques the concepts of both history and heritage are taken to task.

People in societies have always been bound to their environment through extractive and industrial practices. We are interested in how these practices express a sense of place and some actions that can be taken to develop and communicate historical understanding derived from this. We articulate a series of research questions at the intersection of social and physical sciences which are of relevance to the adequate planning of future engagements of local communities in the remediation of forms of pollution which directly affect them.

Key words: artisanal-scale, heritage, history, ochre, smelting

INTRODUCTION

Rapid change in the industrialised nature of the North East of England has led to questions of how to handle the 'heritage' of industrialisation. One specific issue of particular concern relates to sites where ochre deposited from mine water despoils a river. In the particular case which we examine in this paper, the mines in question are old iron stone workings of the Cleveland Iron Ore-field (for a technical account of the mine waters in this area, see Younger 2002) and it seemed logical and fitting that the possibility of smelting the ochre to iron be explored – adding perceived value to the material. The instinctive reactions of all concerned raised questions over the perception of the local environment and 'sense of history' of the location. A simple shaft furnace was constructed using information from archaeological sources to set dimensions. Previous ancient iron-making demonstrations provided information on fuel and blowing rates for the furnace, along with present day

Authors
Aidan Doyle and Jonathan Aumônier, Hydrogeochemical Engineering Research and Outreach (HERO), School of Civil Engineering and Geosciences, University of Newcastle upon Tyne

understanding of the physical and chemical processes involved. The resulting demonstration was some way from a perfect reconstruction, highlighting the problems with a heritage approach to understanding historical realities. More interesting were the reactions of those participating and watching the process.

After examining these issues of perception, we expand on the differences between 'history' and 'heritage', developing an argument which highlights some of the tensions which can arise from our own attempt to engage in practical interventions. A parallel may be drawn between history/heritage tension and the more ancient conflict between scientific understanding and alchemy, the latter in each case being in many ways the more facile of the two, either through negligence or misplaced pride: the metallurgist may be misperceived as an alchemist, through silence or deliberate acts of mysticism.

A DIALECTICAL RELATIONSHIP WITH NATURE

This enquiry stems from an interest in a specific problem of mine water pollution; it concerns ways of looking at the material itself – the ochre – and ways of reconfiguring understanding of this material as a means of addressing the problems that it causes. We are interested in things that identify *this* place, and make it different from other places. Ochreous staining of river beds can be an indication of industrial or extractive activities which have occurred in a place but which, now ceased, no longer contribute to the positive values associated with this place. The reality of place is created by the actions of people in the social world. Social 'actors' have engaged in industrial processes determined by natural factors, particularly the distribution of mineral resources, and the sense of place stems from interactions with the environment – the human ingenuity necessary to exploit them.

PRODUCTION OF SOCIAL SPACE AND THE SPECIFICITY OF PLACE

Across time, people have developed interactive practices which are defined by, and in turn redefine, their location. Every social space is the outcome of human activities, which are invariably grounded in nature. Natural conditions are at the same time primordial and unique. Specific places are always endowed with specific characteristics.

The history of a particular space is considered in the light of the relationship of that space to the time which gave rise to it. The title of Kevin Lynch's book (1972) asks the question *'What Time Is This Place?'*. Industrial activities are located in time as well as space. Minerals become exhausted, with extraction no longer being viable, increasingly because of global economic circumstances. Importantly for the place, due primarily to these economic circumstances, human endeavour is no longer interactive with the landscape.

What is left? Suppositions, texts, absences: the material of history. Interpretation of marks or clues left in the landscape leads to understanding of those social processes which have taken place there. In Cleveland, the principal industrial activity has been the processing of iron. Both absence and blight in the landscape after industry lead to a series of questions, largely to do with how the past informs. What, then, are the clues or marks in the landscape? How do we interpret them? What do they tell us? How are they perceived?

AESTHETICS, DIMENSIONS OF CRITERIA OF RELEVANCE

To examine properties related to perceptions, we turn to the study of aesthetics. Porteous (1996) explains the meaning of the term 'aesthetics', which derives from the Greek *aestheta* ('things perceptible') as 'knowledge derived from the senses'. Aesthetic theories are postulated to develop understanding of certain properties of things which link them to ideals of beauty and taste. What is of particular importance to this enquiry is the notion of an 'aesthetic attitude' which Stolnitz (1960) defines as a 'disinterested and sympathetic attention to and contemplation of any object of awareness whatever, for its own sake alone'. The notion of disinterestedness is crucial to this understanding: the object is not considered for some utility in some other domain, nor can it be manipulated for ulterior purposes. The aesthetic interest cannot be directed towards the object's rarity or monetary value for instance. The sympathetic apprehension concerns our response to the object. When we apprehend an object aesthetically we do so in order to relish its individual qualities, appreciating it on its own terms. It was not the scientific, historical or economic value of the furnace that characterized personal response to it. This apprehension is done through the inhibition of hostile or ideological notions which prejudice the personal response to an object.

Baumgarten reconfigured the subject around the liberal arts (Porteous *loc. cit.*). Objects of his own interest could be endowed and underpinned with scientific theories of the beautiful. In contrast, John Dewey (1934) proposed an active aesthetics of everyday experience to be nurtured, cherished and understood – not reduced to something merely concerning art, for instance,

consigning an object to an art gallery and trammelling aesthetics into spaces of convenience. Through active responses to environment we engage in valuing our surroundings as a whole.

Lowenthal (1985) identifies common themes of ugliness in the landscape as defects: defects of content (scenes spoiled by ugly objects); defects in order and arrangement (beautiful objects badly arranged); defects of vision (the product of greed or ignorance); and defects of social value (environmental inadequacies reflecting deep social malaise). The last two of these returns to the problem of environmental aesthetics as ethics.

There exists a problem attendant on the entrenched 'philosophical belief that beauty lies merely within the eye of the beholder' (Diffey 2000). Mere preference can be closely identified with selfishness. As such, problems in the landscape cannot identify something as being wrong without reasoned argument. Aesthetic descriptions, therefore, further need to be descriptions of objects 'apprehended as phenomenally objective' (Walsh 1970), and must be of the '"it is" rather than the "I am" character' (*ibid*). Engaging aesthetic criteria as phenomenally objective we configure negative or positive qualities in the thing itself, not merely in our perceptions of it. 'The aesthetic attitude involves a certain detachment, a detachment sufficient to preclude the purely personal association' (*op. cit*. p. 240). Making the non-prejudiced, but necessarily sympathetic, value judgment that something is wrong in the environment connects aesthetic understanding with ethics. All aesthetic concerns involve discernment and making judgements, and through the development of taste grows the capacity to discern good and bad things.

The consequence of all of this is that, in keeping with a critical assessment of the environment in aesthetic terms, the deficient or spoiled landscape is not just wrong in my personal apprehension of it, it is inherently wrong. By 'reading a place aesthetically', therefore, it is possible to develop and press claims for restoring its integrity through a fuller understanding of objective phenomena which inform this sensibility. A thing is right when it preserves the integrity, stability and beauty of the biotic community; otherwise it is wrong (Diffey *op. cit*. p. 134.). By these criteria, ochre in the river is wrong and it is proposed that it falls into Lowenthal's theme of defects in order and arrangement. Therefore by rectifying this defect, placing a beautiful object in a correct arrangement, the ochre may be redeemed.

HISTORY

'History' (as a practice, as a scientific discourse) and 'heritage' are terms which are often conflated, yet which generally stand in almost absolute contradistinction. Traditional historiography considers the relationship of a particular place to the times and events that have given rise to its difference. The history of a place – the generative past – leaves its marks on the landscape, indicating human agency with the formation and changes of the landscape through specific practices. Certeau (1998) broadly defines the historical operation as the development of critical understanding of the relationships between a place, analytical procedures (or disciplines) and the construction of texts (literature). Through this analysis he develops an understanding of history as a combination of social space, scientific practices and writing. The exercises which create the capacity to write the history of a place (or time) combine archaeology and anthropology, uncovering the everyday practices of (for our purpose here, industrial working-) life. By critical engagement with simplistic representations, underlying phenomena of realities are exposed.

HISTORY AND HERITAGE

History is in the past, it is something that used to be. 'Designating an event as 'history' means that it is over and done with, that it lacks present and future significance […] the phrase "he's history" consigns someone to a bygone, negligible epoch' (Certeau 1998, p. 168). History is dead and gone. It is no longer of consequence.

We are investigating two types of 'reduction'. The first relates to the art of making iron. The second is about the reduction of experience or the heritage 'project' which modifies former realities for consumption. Heritage is essentially the homogenisation of groups and things, brought together with all complexity ironed out. Collapsing a whole past into a single frame is a common heritage activity, and with this the failure to deal with the reality of experience, of sometimes inconvenient historical facts.

The landscape is redolent with clues to the operations that have modified raw materials and harnessed them to human development. In order for the past to 'inform' the present there is often the need for a reinterpretation of what has happened in such and such a place. This interpretation is the point at which history and heritage part company. Heritage and history take different standpoints. History and heritage both refashion the past in terms of the present. But history does so in order to make the past comprehensible; heritage attempts to make it congenial (Lowenthal 1997, p. 148). Heritage presents the 'experience' right or wrong. It stands in place of knowledge and understand-

ing. The representations which engage in real historical knowledge have been marginalised due to circumstances dictated by economics. 'Dynamic heritage yields dubious history' (Lowenthal 1997, p. 168).

The questions which stem from this enquiry concern what needs to be done to produce something that can be called history. Therefore, how is history made? What can be worked with to make history?

Passing from concerns with notions of a past which was lived and experienced with others and the 'historical past' which 'lies beyond our memories, which is the business of history to investigate' (Cockburn 1997, p. 243), we turn to the past which we reconstruct through inference. The past consigned by and to history leads to questions about what we know and what we think we know about a given subject. Iron, especially iron processing of a long time ago, is an important example. Much of what we are presented with is based on conjecture, and we will demonstrate that this can arise from the supposition that people who lived a long time ago, and made iron, were less adept, less capable of understanding the material they were handling.

Evidence of early ironmaking can be found in the North Yorkshire Moors, Durham and Tyneside (Tylecote 1986). These early workers used ore from small outcrops of magnetite rather than the ironstone that was later exploited in the boom of the Cleveland Iron Masters. The nearest archaeological site to our activities is at Levisham, and displays remains of a furnace type otherwise unique to Siegerland, posing many questions about the migration of ideas and skills. Here also the Romans are believed to have roasted iron for their use – their skills influencing local iron production techniques. Viking smiths knew iron well, and Kliffland names such as Skinningrove and Skelton are taken from their language. By the time of the Reformation the Abbey at Rievaulx ran a vibrant ironmaking centre in Bilsdale, having developed from the bloomery process to the use of the blast furnace. This allowed a greater variety of ores to be exploited. Writings of more recent history claim the newness of understanding of the use of iron found on the foreshore at Saltburn, and its uses in the furnaces of Lemington and Jarrow on the Tyne in the 1840s. Iron mines were opened out all along the Cleveland Iron ore field by Tyneside industrialists.

Bell (1902) gives a powerful description of the 'works' at the end of the nineteenth century – the raw material of global industry, and at an immense global scale. She witnessed the process through which 'gasses were driven into the furnace at the top of the hearth, just above the slag opening, by blowing engines', 'Four times in 24 hours the furnace is tapped'. Today the furnace at Redcar is tapped continuously, producing over 5 tonnes of iron per minute, which is itself more than the entire world production in the mid-1880s, which is an interesting observation, given the general perception of the Teesside steel industry as one that is all-but dead. The production may still exist in terms of tonnes, but its role in defining the local space (and the relevance of this local space to the global iron and steel markets) is much diminished.

PRESENT DAY REALITIES

Something happened in the global economy, and the industrial production of iron and coal and other primary commodities in the North East of England stopped. Lynch (1976) has described the 'inhabited landscape [as] a medium of communication', and its 'messages' affect our 'performance, cognition, development, and emotional and aesthetic satisfaction'. Taking into consideration the various forms of available information which enable us to assess understanding of a place after extractive or process industry – are they messages that effect modes of understanding, or are they interpretations?

We investigate ways of recovering the meanings encrypted in this landscape through developing ways of understanding historical reality rather than heritage.

NATALITY AND POTENTIAL

'Because the urban landscape stimulates visual memory, it is an important but underutilised resource for public history' (Hayden 1995, p. 47). Historic urban or industrial landscapes associated with productive activities carry the narrative of how these processes have evolved across time, and can be investigated to yield foster sense of belonging – creating public history through the use of the problems.

Hannah Arendt proposed the concept of 'natality' as the capacity for individuals to make significant contribution to their society in times of profound change. Nye (1994, p. 151) explains this natality – 'capacity to do new things' as '[a]ction, like a child […] born into a world of human relationships in which it must find its own place'. Lynch adopts the possibilities afforded by this simple idea, particularly where the environmental problems are a direct cause of social changes (changes in which people are left behind, their way of life becomes archaic and despised, their social practices are excluded from common participatory opportunities). He defines the need for an environment which must be open and in which people can easily penetrate and participate, in which 'we hope to make environments which accept change. And also to manage […] change so that it does not degrade the living community' (Lynch 1976, p. 771).

So the dirty water becomes the vehicle for rooted actions, activities which encourage the communication of the sense of the place itself. How is this place different and what stories can we obtain from it? How can this sense of difference be conveyed? Arendt defines the space of natality, of creativity, as agency or *voluntas*: we don't choose our circumstances, but we are here at this place and at this time, and so we make decisions to act, we make plans and act accordingly, intersecting with other people's lives as we do so. Engaging in a rooted way with the problem of the environment we are investing the problem itself with creative potential. Since one of the givens is the inherited body of understanding, craft skills and common sense knowledge of the material itself, natality is rooted in the aesthetic experience of everyday industrial working life. It is difficult to summarise this knowledge (present as text, or heritage); due to its extent, it cannot easily be reduced or compressed.

The project proposed to use the problem as the stimulus for learning, and aimed to develop programmes that conserve historical continuity. The place was and is about the production of iron, in one form or another. The aim was also to investigate this history through the traces that it leaves in the environment.

EXPERIMENT IN IRONMAKING

The term 'reduction' means different things in chemistry and in social sciences. In the former, reduction can be defined as the opposite of oxidation, or reactions in which atoms in the reacting materials gain electrons. In the social science context, reduction has negative connotations coextensive with the proof of falsity of a statement through demonstrating that logical consequence is absurd (*reductio ad absurdum*), or it can mean banalisation through simplification – the distillation or impoverishment of a concept to the point of pointlessness. Reduction in the historical sense is the grouping and homogenising of facts and events, modifying realities for consumption, removing the complexity and ambiguity. In preparing material for its target, the consumer, it fails to deal with the realities of experience. In the metallurgical sense it is stripping away bound oxygen (or other elements of the compound) to reveal the elemental metal in its pure form, usually associated with positive outcome.

We are working with aesthetic assumptions of objective phenomenology: that there is something wrong with the environment; that a sustained effort can put it right, that blame ought not to be apportioned to the material itself. There is an expertise which is currently unused and which, given the opportunity to participate in the revival of the landscape, has a potentially vast contribution to make in terms of aesthetic representation as well as understanding of process and place.

As outlined earlier, our programme of work concerns the reconfiguring of the ochre despoiling a river bed as metallic iron engaging knowledge of processes which have created the landscape (and contributed to its problems). We are interested in the adduction of understanding; in bringing knowledge about ironmaking and process so as to broaden and deepen acuity in its general field.

Ancient processes for ironmaking display numerous variations in method, techniques and construction; however, they were all based on the same metallurgical process of solid state reduction of iron with carbon from charcoal. Heat is supplied by the initial combustion of charcoal in a draught of air, the resulting gases reacting with further charcoal to produce a gas rich in carbon monoxide with high reducing potential. The gases reduce the iron oxides to metal but the temperatures reached, 1200°C, are not enough to produce a molten product. Any gangue materials in the ores are therefore trapped as slag and must be removed in a further process of smithing the resultant iron mass (or bloom). The slag chemistry relies on the low solidus temperature of fayalite (ferrosilicate), 1177°C, to produce a slag which can be removed from the iron by this method. The requirements for the ores are therefore to be high in iron content and have gangue that is predominantly siliceous. For ochre, roasting will remove the bound moisture, so by the time the material reaches the reactive area of the furnace it fulfils the criteria for successful smelting (similar roasting of ores was used for ironmaking from siderite deposits).

In the earliest cases, the ironmaking furnace was simply a bowl-shaped depression in the ground, into which charcoal and ore were placed and air blown through an inclined tuyère. The tuyère is a small aperture through which gas or air can be blown into a furnace, it may be integral with the pipe used to convey the air or consist only of the tip produced from material to withstand the high temperatures generated from combustion at the point in which air is introduced. Many early examples of tuyères produced from fired clay have been found from all ages of ironmaking. The bowl furnaces developed into small shafts, taking advantage of natural draught for preheating and to provide some of the process air. Some examples have been found where the complete smelting process is conducted through natural draught generated in the furnace; this was the method used in some ironmaking processes operating in Africa and India in the first half of the twentieth century. With the shaft furnaces came the possibility of tapping molten slag from the furnace, the removal of slag allowing more room in the furnace

for the bloom and hence increasing the possible production from each furnace run.

THE FURNACE

The research began by building a simple furnace similar in dimensions to those that may have been used at the time of the Roman occupation. The furnace was 700 mm high (an arm's length from the top to ease access) with an internal diameter of 300 mm. Although our construction was from brick and local stone to aid fast assembly, archaeological evidence points to the use of clay which (through our experience) proved to be a far more durable method, though needing careful drying. Use of fossils and unusual ironstone on the outside of the furnace improved the aesthetics to our modern eye. The eerie blue flame dancing on the top of the furnace held onlookers captivated, lending a mystical aura to the technically driven proceedings. At this juncture the distinction between metallurgist and alchemist could be said to have retreated; history became myth once more.

To remove the iron bloom without demolishing the shaft furnace, which represented a significant investment in time and effort to the early ironmakers, an opening was constructed in the side of the furnace at the base. In this case the 'furnace arch' measured 300 mm high and projected out at the full diameter of the furnace. The furnace arch also provided a means of lighting the furnace with wood from the bottom and heating with natural draught air. Once air was blown into the furnace, the arch was blocked with clay and turf. A single tuyère with an internal diameter of 19 mm projected into the furnace 300 mm up from the base and with a downward angle of 10° below horizontal. This mirrored archaeological evidence and provided sufficient room for the bloom to develop beneath.

The furnace was fed with a mixture of ochre and siliceous iron ore (our local supply of dry ochre ironically proved insufficient on the day!). Initially batches of 2 kg charcoal and 500 g ore were added to preheat the furnace, the ore being present to flux the ash from the charcoal. Once the furnace was nearly full, the mix was changed to 1 kg of ore and 1 kg of charcoal for the remainder of the run. From lighting to removal of the bloom the furnace was worked for nine hours. In all, 29 kg of charcoal and 20 kg of ore and ochre was charged. A compressor was used as the air supply to the furnace; this proved to be the biggest reduction of the operation in the historical sense. Through this the experience of effort required to maintain the temperature in the furnace was lost; it removed the incentive to maximise the natural draught in the furnace and pre-roast the feed materials, bringing about a different relationship between the adept and the apprentice. The impression was that iron made itself 'as if by magic'; the toil of the ancients was lost. At the end, a bloom of 11 kg, glowing red, was removed from the shaft. This bloom is ready for direct smithing into whatever objects the local residents might deem fit.

CONCLUSION: MISTAKES, MORE QUESTIONS

The reuse of ochre was investigated in conjunction with the reduction of other iron oxides. Through this the primary intention has been to open up access to historical knowledge, and invite the participation of experts and people with everyday experience of metallurgical processes to contribute to this understanding. The aim has been to develop a setting which increases openness and adaptability of these givens to different possibilities (in both historical and heritage contexts). This we believe can encourage public celebration of the difference suggested by specific aesthetic realities.

Early observations concluded that exponents of the iron arts in 'primitive' or earlier civilizations had acquired an extensive knowledge of materials and process that superseded any accidental happening upon metals for domestic or military use. The skills and expertise that have evolved over millennia have, through economic programmes of industrial reduction, been centrifugally compelled beyond the limits of potential contribution to continued understanding. Is there a danger that this knowledge, and similar understandings from other fields and disciplines, will disappear altogether? By becoming 'history', is it possible that it can only have a place in the consumer representation which is heritage?

From this work it is intended to set up a programme of public participation in education as a means of mitigating environmental problems, orphaned after technical understanding which went to create them has decamped. The project is capable of transmuting dead, or moribund, and speculative information into living, educational, operative practices. Opening channels for communicative actions may contribute to the thinking that will be necessary for the regeneration of places orphaned with the departure of extractive and processing industries, through inviting the participation of practitioners of those industries.

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