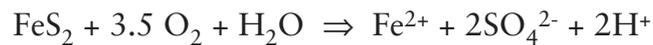


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Spoil from collieries falls into one of two categories – fresh spoil and weathered spoil. The two have very different characteristics both physical and chemical. Firstly, fresh spoil tends to have a pH value of between seven and eight. Weathered spoil can be very acidic, values as low as pH 2.5. Secondly, as spoil weathers, the size of particles within it decreases which may lead to problems of stability.

To reclaim an area of colliery spoil it is necessary to put pollutants at a depth greater than 1metre to stop the oxidation of iron pyrite and then to cover the area with clean topsoil (In the case of many new open cast sites, the original soil is stripped at the commencement of mining.)

The oxidation of iron pyrite contained within colliery spoil is the main cause of ecological problems associated with coal mining. Iron pyrite (FeS_2) is a naturally occurring compound in Carboniferous rock and when in contact with oxygen and water oxidises as follows:



The resulting compounds are iron, sulphates (which combine with other elements) and hydrogen, which are combined with a lower pH value, toxic soils, water contamination and an increase in temperature. The deterioration of soils in and around spoil heaps means that only species tolerant to these ecological extremes can survive, yet vegetation is needed for the reclamation of colliery sites. The area indicated in the map below (Figure 4) is the area in which colliery spoil has been deposited, regraded and revegetated. This area is now vegetated with alder (*Alnus*), hawthorn (*Crataegus monogyna*) and birch (*Betula*), all very good for reclaiming coal environments, and also other deciduous species of trees. On the surface it is possible to see pieces of equipment left behind, brick fragments, coal and metal all being very evident. Looking beneath the surface it is possible to see how the coal has affected the soil. Over much of the area the soil is distinctively darker in colour than the soil found in neighbouring areas.

Another effect of pyrite oxidation is the pollution of ground and surface water, popularly known as ‘acid mine drainage’. Due to Prestongrange’s long and difficult history with flooding, large volumes of water have passed through the mine’s workings and shafts. The effects of oxidisation will have influenced this water, which is the cause of acid mine drainage.

Acid mine drainage is a by-product of the mining industry

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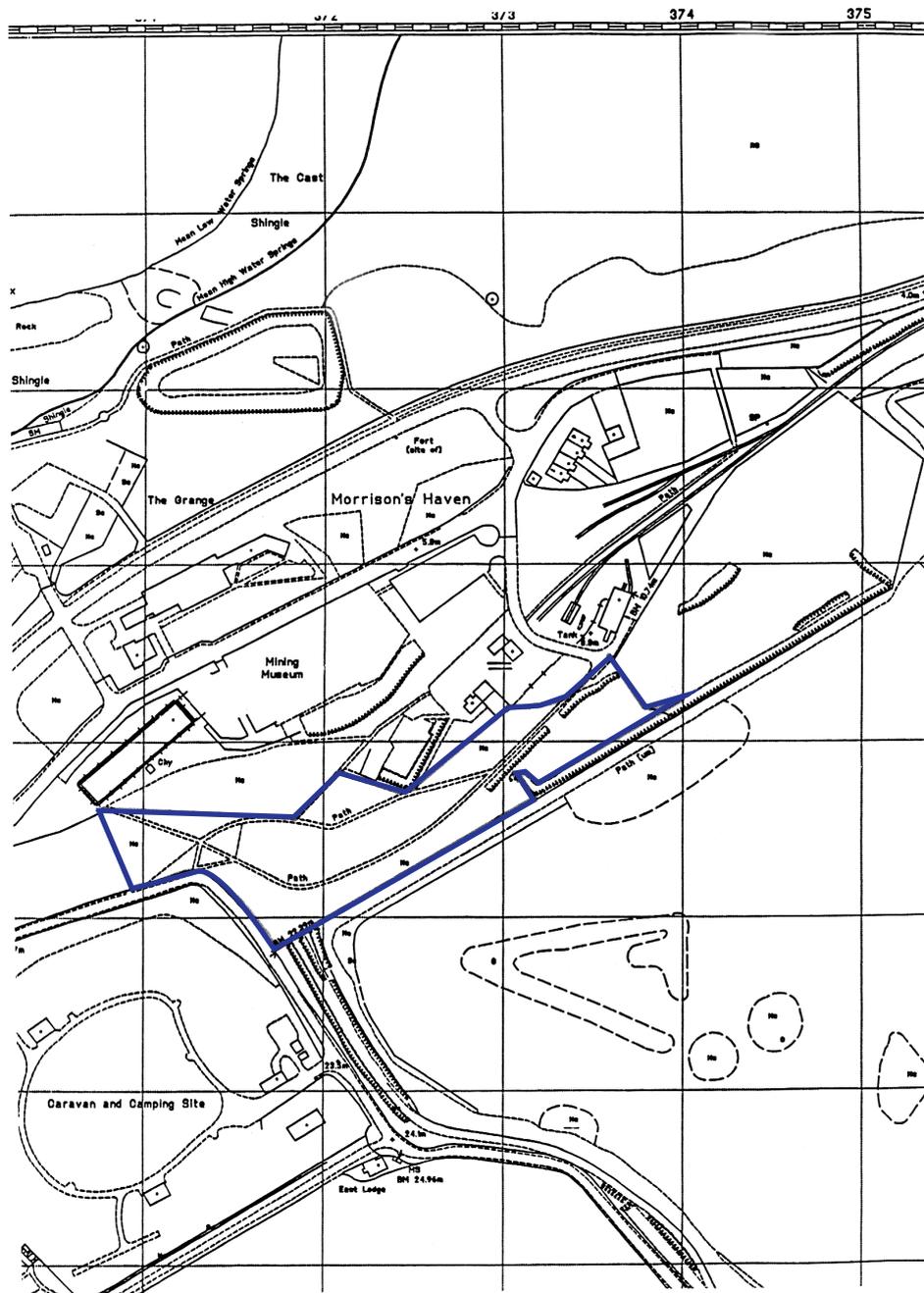
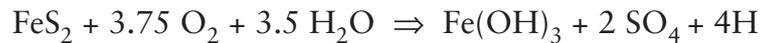


Figure 4 Map of areas known to be covered by colliery spoil

that is very distinctive, due to its yellow-orange colouring of watercourses and sulphurous odour. (Runoff water at the Industrial Museum frequently demonstrates this effect.) The chemical equation for the reaction is similar to the above, only that due to large water volumes the reaction products are Iron Hydroxide ($\text{Fe}(\text{OH})_3$) and Sulphuric Acid (H_2SO_4).

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The effects to watercourses of acid mine drainage can, in severe circumstances, destroy ecosystems by having two direct effects: (i) lowering the pH value of the watercourse thereby directly killing organisms, and (ii) coating river beds and shorelines thereby stopping plant and algae growth. Organisms are killed because the acid water reduces the sodium ions in the blood, which in turn reduces the amount of oxygen in blood (Reinhardt). The iron hydroxide in the water will coat itself onto the river bed or shoreline turning the bed a yellow-orange colour and making it difficult for plants to survive and produce oxygen for the animals and fish, thereby reducing population numbers. Such pollution long ago made impossible the continuation of the oyster farming at Prestoungrange.

Water contamination caused by mining can be reduced through a number of techniques including limestone channels and artificial wetlands. These are as close to natural treatment as is possible and are effective for lower levels of contamination and are relatively cheap. Other techniques involve using alkaline chemicals to neutralise the acidic chemicals in the water. Such chemicals include calcium carbonate, calcium oxide, calcium hydroxide and sodium carbonate, all of which have the aim of raising pH and removing metal concentrations from the watercourse.

Chemical treatments, however, are considerably more costly. Compared to limestone, which can be bought for around £10/ton, even hydrated lime costs around 6 times as much (from Skousen et al. 1999, via Reinhardt).

The surface evidence indicates little acid mine drainage at the Prestongrange Colliery. Discoloured water is present around the winding gear adjacent to the beam engine but this is likely to be the effects of rainwater being discoloured by rusting equipment and structures. However, it is impossible to see what is the current extent of any underground contamination that has taken place as the colliery was closed and all shafts sealed in 1962.

Particulate matter in water (held in suspension) may also have a detrimental effect on fish health in that their feeding habits may be forced to change. This may be as a direct result of food being destroyed, or it may be that increased particulate matter leads to a decrease in algae and therefore dissolved oxygen levels. As there are no watercourses around the Prestongrange site, the direct effect on fresh water

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organisms is likely to be close to zero but the shoreline will be differently affected.

Due to the large volumes of water that Prestongrange Colliery has had to contend with, any contaminated water created has a greater chance of being transported away from the colliery than an inland colliery due to its proximity to the Firth of Forth. This means that any contamination may well have been carried out towards the North Sea or diluted by the large volumes of water passing through the mine.

Subsidence

Subsidence is another extensive problem associated with areas of mineral extraction. There appear to be no such problems affecting the area around Prestongrange but there have been extensive works carried out to level and reclaim the site so any subsidence may have been hidden from view.

Subsidence affects many regions of Britain and is particularly prevalent in the Midlands and the salt fields of Cheshire. The diagram below illustrates a typical case of mining subsidence in similar geological structures.

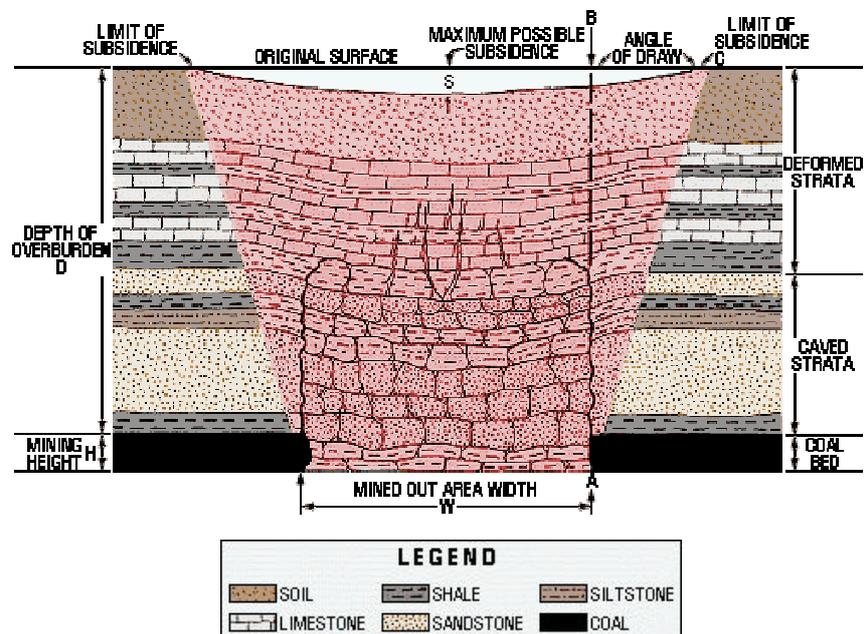
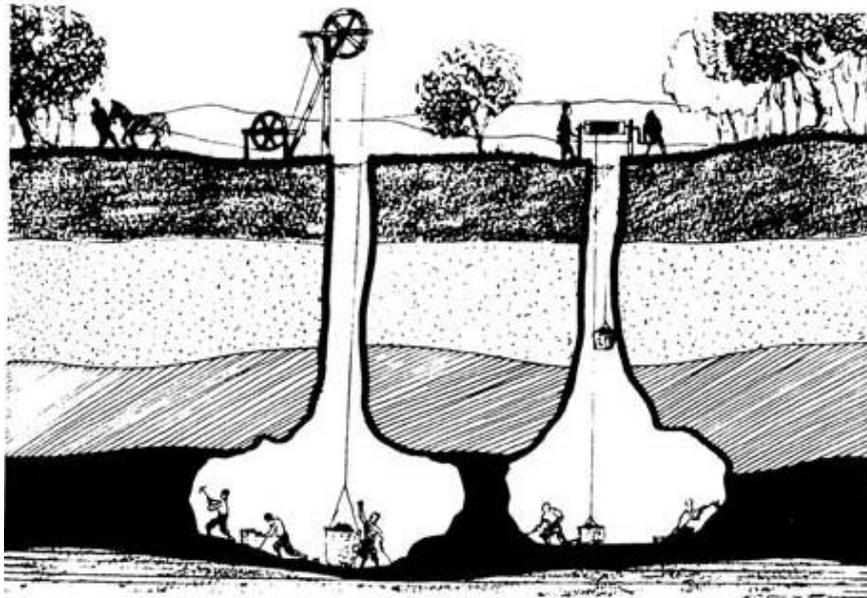


Figure 5 Subsidence
West Virginia Geological and Economic Survey

There is good reason to suspect subsidence at Prestongrange, and even more in the area of Prestonpans at large. Coal

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mining, both on the surface and underground has been undertaken since the twelfth century and across the millennium mining methods have changed considerably. If mining was undertaken below the surface then it is likely that ‘bell pits’ were used, illustrated in Figure 6. From this it can be seen how easily subsidence may occur if the walls of the pit collapsed inwards.



A cross-section of a bell-pit mine, the first system of underground mining

Figure 6 Bell Pit

Courtesy of Keele University via Coal Mining in Staffordshire (Staffordshire Multimedia Archive)

Later methods included ‘stoop and room’ and ‘longwall’. The stoop and room method involved mining coal in ‘rooms’ leaving ‘stoops’, pillars of coal, to support the roof. The longwall method, as the name suggests, involved cutting a wall of a seam of coal, using artificial props to support the roof. After pit closure, the temporary supports are either removed or left to rot away, which will readily create the situation illustrated in Figure 5.

The owners of any development that suffers subsidence can make a claim for the damages from the government, the costs of which can be recovered to a certain amount through the Coal Mining Subsidence Act 1991 (The Coal Authority⁴). Measures can be taken to avoid subsidence in new developments

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by undertaking surveys of historical land use. If however the subsidence is happening to an existing development then structural measures can be taken such as flexible services (gas, water etc), strengthening and deepening of foundations and more flexible building materials, timber replacing concrete.

Coal Dust

Coal dust is also a problem of coal mining, however, it tends to occur only when the mine is operational or if there are bare spoil heaps, so the problem is no longer an environmental issue at Prestongrange. At the time of mining, dust was the cause of many bronchial illnesses, but the majority of cases will have been caused by dust from underground mining, as there are no records of large scale surface mining in the area around Prestonpans.

General Reclamation

Apart from the problems described above, the site must also undergo regrading. The land must be levelled out, stopping any potential stability problems and new topsoil laid over areas that are to be revegetated. Revegetation is usually carried out with agricultural crops or through forestry and the most widely used crops are oilseed rape, cereals and wheat. Trees best suited to these conditions are alder and birch. A grass cover is also essential for securing the topsoil and stopping it being wind blown (see Hester and Harrison).

Salt

Of all the industries that located themselves around Prestonpans, salt is the most significant historically and has the most direct ecological problems for the environment after the colliery.

Salt was the first product to come out of Prestongrange and the town of Prestonpans owes its name to the industry. Previously known as 'Saltprestone', the name Prestonpans is derived from 'Priests' town' and 'pans' relating to the salt pans.

The production of salt dated back to the Monks of Newbattle Abbey who were producing it as a food preservative but later it was used in the production of other materials such as glass and soap (see Anderson).

Salt production hit a peak in the early eighteenth century, when cheap imports from the Cheshire salt fields made production far more efficient, as the salt was purer than the Firth of Forth marine salt. This was at a time when Morrison's

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Haven was a thriving harbour, a fact which was undoubtedly central to Prestongrange's success.

Sulphuric Acid (Oil of Vitriol) was also produced around Prestonpans and is also a by-product of salt production. It is as harmful to the environment as sodium and chlorine compounds and is dealt with below.

Figure 7 Approximate Composition of Sea Water (Cheetham Salt⁷)

Salt	Percentage
Sodium Chloride	2.68%
Magnesium Chloride	0.32%
Magnesium Sulphate	0.22%
Potassium Chloride	0.07%
Calcium Sulphate	0.12%
Other salts	0.01%
Water	96.58%

[N.B. From every kilogram of seawater, approximately 35g of salt will be obtained]

The production of salt is not only potentially hazardous to the environment at the time of panning but later because salts left in the ground can lead to health problems for plants, animals, fish, soil and humans.

The process itself, until the onset of the industrial revolution, involved using iron or lead pans to evaporate seawater to leave salt crystals in the pan. This process was not very detrimental to the environment, but the waste being poor grade salt, will normally have been deposited around the area and have been leached into ground water.

During the process of salt production chemicals such as Sulphuric Acid (H_2SO_4) are produced, which have a detrimental effect on the environment, but once sodium (Na) and chlorine (Cl) pass into the ground they can kill whole communities of plants and micro organisms. The presence of excess sodium or chlorine in the environment increases pH from around pH5.5 to as high as pH10, as sodium replaces calcium in an anion exchange, making soil less hospitable for vegetation. Sodium also makes soils less permeable and may even cause a 'hard pan'; a layer of salt encrusted soil, to form, which prevents plants from getting at groundwater.

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The salt also has the effect of reducing the moisture content of the soil, making it more difficult for vegetation to grow.⁸ Root growth hindrance means the plant is less able to access water unless it is a halophyte or salt loving plant (see US Salinity Laboratory).

It is very difficult to regain an ecosystem after salt processes, whether human or natural, have affected it. The location of Prestongrange may help to ameliorate these effects, due to its proximity to the sea. The natural state of the ground and groundwater may be expected to have higher benchmark salinity than further inland and the local vegetation and micro-organisms to reflect this.

Heavy Metals

Heavy metals are elements also known as transition metals and are found in the middle section of the Periodic Table. In relation to mineral waste, they are often compounded with a salt or are oxidised and can be released into watercourses if leaching occurs. Some of the commonest heavy metals associated with the coal and brick industry tend to be iron, copper, lead and zinc.

The salts that these are often compounded with create sulphates, hydroxides, and carbonates and, with respect to the brickworks, silicates. Oxides are readily formed when the spoil material is weathered and iron, copper and zinc form oxides which may later be transported into watercourses, or left in the soil to hinder revegetation.

Iron pyrite is once again a major contributor to contamination as can be seen from the reactions below and purely through exposure to water and oxygen can produce a wide range of other chemicals.



This reaction produces iron sulphate and sulphuric acid. These then combine with water in the following equation to produce ferric sulphate and water:



The following reaction combines ferric sulphate, sulphuric acid and water to produce an iron hydroxide and further sulphuric acid:

