LEAD MINING AND SMELTING

with particular reference to the Pennines.

The size of the industry.

Statistics available only from about 1850, which was towards the peak of the industry.

1856. Total British production of lead = 73,129 tons.

Made up of 40,422 tons from Pennine area

Derbyshire 6,261 tons
Yorks 9,000 tons
North Pennines 25,000 tons
(incl. Beaumont mines 9437 tons
and London Lead Co. 7,000 tons)

15,000 tons from Wales (Cards and Flints)
6,600 tons from Cornwall

Silver found with lead, amounted to 614,000 oz
(or 20 tons)

made up of 250,000 oz from Cornwall
156,000 oz from North Pennines
60,000 oz from Wales
60,000 oz from Isle of Man
negligible from Derbys and Yorks

By this time, British lead production could not meet demand, and there was much importing of cheap foreign lead, so price had fallen from around £33 in 18C2-04 to around £20 per ton (a minimum of £13.10.0. was reached in 1832 due to competition from Spain). This makes the total value of the British lead industry about £1. 5 million per annum, plus whatever the silver was worth; say a total of over £2m.

Geography and geology of Pennine lead areas.

The main lead ore is galena, lead sulphide.

Far less widely distributed than iron ores. Occurs only in more recent rocks into which a layer of granite has intruded. The veins of lead ore are often very thin (often only a few inches) and are bounded by "gangue", i.e. "non-metallic" minerals such as calcite (calc. carbonate), barites (barium sulphate), quartz (Si oxide) or fluorspar (calc. fluoride). Since miners have

to excavate a passage large enough to crawl through, they necessarily have to excavate large quantities of these other minerals from which the lead ore has to be largely separated by "dressing" to produce a "concentrate", which may contain 70% of lead ore. Hence spoil heaps.

(N.B. Since the efficiency of dressing was low in earlier days, it is sometimes economic to go over old spoil heaps to extract the remaining lead ore without mining in the true sense.)

The Pennines are mainly limestone. The scenery is magnificent, and some of the special limestone features such as limestone pavements, Malham Cove, and the "scars" and crags are spectacular. The limestone itself is a useful mineral, being burnt to make lime (hence old lime kilns are found all over the place), and being used as a flux in iron smelting (hence the huge limestone quaries above Stanhope in Weardale, the nearest limestone to the North Durham iron-smelting district (e.g. Consett, etc.)

In Teesdale (among other places) there is an intrusion of Whinsill, a very hard rock, and this is much quaried and crushed for roadstone.

The lead veins are widely distributed over the areas in which they occur, and thus we find remains of the lead industry all over these high moors - often at 2000ft elevation in conditions of the utmost bleakness in winter. The life of the lead miners was very hard - and that of the other workers, such as transport drivers.

Early history of lead mining in Britain.

The Romans mined and smelted lead in Britain. Pliny, writing before AD77 mentions that so much lead was produced that a law to restrict it had to be introduced. It seems certain that lead was being produced in the Mendips by AD50, in Flintshire by AD 70 approx, and in Shropshire by c.AD 120. In Yorks by AD81. Romans were already producing lead in Spain and so had the technical knowledge.

It is thought that the Romans originated the process of ore extraction known as "hushing", which remained in use until the end of 19th century. A turf dam is built near the crest of a hill slope, and when enough water has collected the dam is broken. The torrent thus released rushes down the slope,

tearing away the soil and broken rock. If veins of lead are present in the ground, weathered pieces of ore are carried down and may be collected from the heap at the bottom. Also the veins may be detected for further excavation. The spoil heaps from this process are easily seen today, though probably only from more recent work!

Another method was "opencast": cutting a trench along the sides of a vein outcropping in the surface, and merely hacking out the lead ore.

The ore was crushed, washed and smelted in the area of the mine. Lime and silica seem to have been used as flux. Silver was extracted from the lead after the first smelt, before further refining of the lead took place.

The great Roman demand for lead was largely due to their baths and need for water supplies.

The Pennine lead mines probably fell into disuse from about AD187 to the 9th century - originally because the natives rose up against the Romans in the area. In the 9th century the lead mines seem to have been operated by the monasteries, and later by the Danish conquerers. The terminology of the mines and miners seems to date from the Danish period. Lead was not in much demand however (unlike iron) and its main use seems to have been for roofing large buildings such as churches. Medieval use however increased, and there are plenty of records of it, including the routes by which the lead was transported. By the end of the 15th century the trade was quite large, individual transactions often being of the order of 100 tons. Some thousands of workers were employed - men and boys in the mines, women and girls on the surface, e.g. for dressing the ore.

Techniques.

Mining.

In the early days the mining was restricted to shallow surface grubbing and to hushing. Trenching was restricted by collapse of sides and by water. Similarly shaft sinking was restricted, not only by collapse and flooding, but by lack of ventilation.

In shaft mining, the "bouse" (or ore and rock) was removed by winding up buckets, and it was usual to work in 50ft lifts. Deeper mines had successive 50ft shafts offset for convenience in lifting. By 1630, depths of 300ft were reached. Draining was necessary, and much was done by hand using buckets. In the 16th century the "rag and chain"pump was introduced here and there. For 20ft lift, 4in pump employed 20 men working 5 or 6 at a time in 6 hour spells. Adits were used from 14th century, but represented a large capital outlay, Other names were "water-gate" and "sough".

Steam pumping introduced in 1748.

The tools used by miners were the pick and wedge, also crowbar and hammer.

Dressing: The bouse was divided into "knocking" ore - large lumps of rock and ore easily separated by knocking with a hammer - and "fell" or smalls. The clean ore, picked out by hand, was sent direct to ore container. The rest was brocken down by women and boys to 1/4" size, picked over and washed. By the 16th century, the "buddle" was used - a channel of wood 1 to 2ft wide and a few feet long, slightly sloped, water ran down it. Crushed ore placed at top and stirred. Water carries off stone and spar which is relatively light, leaves lead ore which is heavy. Sieve and tub also used from 1565.

Smelting: Romans used small furnaces. But these went out of use and were replaced by a very primative process called "boles". On a suitable hill (a "bole-hill") a small area, a few ft diam, was worked around, leaving openings on the windward side. A fire of wood (or peat) was lit, ore sprinkled on it, more wood, more ore, and so on. Lead produced ran out by a small channel and was collected. Bellows were used to supplement the wind by 1304. At first operated by men, later by waterwheels.

In the 16th century, furnace came into use, then the ore-hearth. Very crude, not much different from bole, but coal used and forced draught exclusively. More efficient than bole. The ore-hearth is rather like a box, built of firestone, about 24" x 22" x 14" deep. Attached was the "workstone" which is its unique feature and made of cast-iron. The ore was placed on the cast-iron hearth and heated sufficiently to partially oxidize it without melting. When it began to soften it was raked to give a fresh surface. When about half oxidized, drawn out into water and then dried. Then returned to hearth, mixed with coal and peat and heated, using blast. Slag separated at frequent intervals, and lead run off.

The reverberatory furnace came in during the 17th century, and was used for lead at the end of the century. The flames and heat from burning fuel were reflected onto the ore in a second chamber. Thus impurities in the coal did not get into the metal. Draught created by a tall chimney without bellows. Smelting and refining done in REVERB furnace.

The 19th century.

Saw great developments - although mainly underground. The lead mines, grouped into a few large companies, were able to undertake larger capital works than previously. They were able to drive long "levels", or tunnels, for drainage and transport, and cross-veins. This enabled the ore to be extracted efficiently, and the capital expenditure appears to have given a good return.

Examples. Alston Moor. Mines owned by Greenwich Hospital, employed Smeaton as consultant. He built Neut Force level, 1776 onwards. This ran from beside the waterfall of Nent Force (near Alston) on the R. Nent for 5 miles to a point below the village of Nent Head. It is mostly of 9' x 9' section, but was larger in places. The first 2 . 7 miles are quite level and were kept with 4' depth of water and used as a canal for 30ft barges to bring out ore. Beyond that there is a vertical step of 210ft which forms a great waterfall. It successfully drained a huge mining area.

Old Gang Mine in Swaledale. Many levels constructed for horse traction using tramways. Although Aldersons, who constructed much of this network, had to give up the lease in 1828 through overspending, their successors, Jaques and Co., reaped the benefit, since this mine kept up an annual output of lead exceeding 1000 tons for many decades.

The London Lead Co. was one of the very big companies operating on Alston Moor, in Teesdale, and elsewhere. Their Alston Moor network became very complex, based on Nent Head, a village which they constructed especially to serve their mines. All levels drained by flow to the Nent Valley.

Techniques of ore-getting improved. Cast iron rod used for boring rock 1851. Dynamite 1863 replaced black powder. Rock-drills introduced in Pennine lead mines 1870, using waterwheel to drive air-compressors. Ore-dressing also improved. Crushing rollers replaced hand breaking from 1796 on. Machine-driven seiving (in water) introduced also. Smelting continued using ore-hearths and reverberatory furnaces.

Fumes from lead smelting are toxic, and the practice of building long arched flues up the hillside to a chimney at the top developed. Some of these were 2 to 3 miles in length and their remains can still be found on the moors.

Extraction of silver from lead. From Roman times to 1833, done by process called cupellation, in which the lead was oxidized by air blast and the litharge blown away, leaving silver: needed many repetitions, of course, to get adequate refinement. In 1833 Pattinson introduced crystallization process. On cooling in correct way, molten lead developed crystals which could be easily removed, leaving a higher concentration of silver behind. The old process needed 6oz of silver in the ton to be economic; the new needed only 2-3oz.

Transport. Until the early 1830's the ore and lead was transported almost exclusively by pack horse in the moorland area. Rivers and canals used where possible for later stages.

Turnpike roads later greatly helped.

Railways were built at least partially for the lead traffic - e.g. Stanhope and Tyne, Weardale, Teesdale, etc. See booklet by Rounthwaite.

Free Miners. It is worth noting, in passing, that the Pennine lead areas had a system of free miners (see Raistrick and Jennings, p 169), just as the Forest of Dean had for coal.

References to lead-mining in the Pennines.

1. A. Raistrick and B. Jennings, "A History of Lead Mining in the Pennines", Longman, London, 1965.
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3. T. E. Rounthwaite, "The Railways of Weardale", Rly. Corres. and Travel Soc., 1965.
4. R. T. Clough, "The Lead Smelting Mills of the Yorkshire Dales", Leeds, 1962.
5. K. Hoole, "A Regional History of the Railways of Great Britain", Vol. 4 - The North East", David and Charles, Newton Abbott, 1965.