

## **HISTORICAL REVIEW PAPER THE SHALE-OIL INDUSTRY IN SCOTLAND 1858–1962. I: GEOLOGY AND HISTORY**

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*Scotland was the global pioneer of the modern oil industry and, for a few decades in the second half of the 19<sup>th</sup> century, was the leading oil-producer in the world. The history of the shale-oil industry in the county of West Lothian, Scotland is unique within the United Kingdom. This paper briefly reviews the geology of the oil-bearing shale beds and the history of the Scottish shale-oil industry.*

### **Introduction**

The Scottish shale-oil industry centred in West Lothian, a small county located on the southern shore of the River Forth between Glasgow and Edinburgh, with an area of 427 km<sup>2</sup> [1]. The present-day landscape is largely agricultural, industrial and urban; a record of the exploitation of the rich soil and the underlying geology. West Lothian has been mined for the diverse mineral deposits under its rich glacial till [2] since 1165 when monks first extracted coal at Carridon [3]. This long history of mining expertise was beneficial to the Scottish oil industry from 1850 but became invaluable from 1858–1962 when a commercial use was found for the expansive oil-bearing shale field that lay under almost half of the county. An expertise that continues to be of value because the production of oil from oil-bearing shale is once more the focus of Global attention as the availability and accessibility of free-flowing oil diminishes in the 21<sup>st</sup> Century [4].

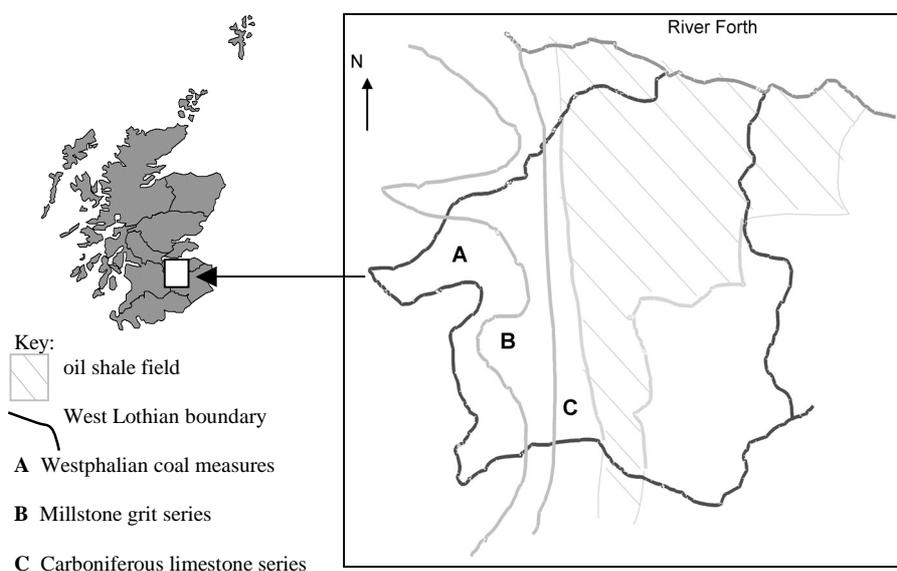
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## The geology of West Lothian

West Lothian lies in the Central Scotland rift valley formed between the Highland Boundary and Southern Upland faults. During the Carboniferous Period, when Scotland lay on the Equator and experienced a tropical climate (360–285 million years ago) warm seawater flooded across the central Scotland valley in a vast tropical lagoon named Lake Cadell [5]. Limestones developed from the coral reefs and coal was formed from the surrounding swamp of primitive plants under great thicknesses of sandstone. In the centre of the lagoon layers of fine silt and plant debris were deposited by the tides to form oil-bearing shale, a sedimentary rock containing varying amounts of solid organic material (kerogen). The shale fields never contain any liquid oil but the parent rock, when heated to 500 °C, yields hydrocarbons in the form of paraffin and crude oil [3]. In West Lothian, oil shale is found in a broad band from the Firth of Forth, between Blackness and South Queensferry in the north to West Calder and Addiewell in the south, an area of 194 km<sup>2</sup> (Fig.).

The West Lothian oil shales occur in Lower Carboniferous strata in the Upper and Lower oil-shale groups [7]. The strata of the West Lothian oil-



*Figure.* Simplified geological map of West Lothian (adapted from [5, 6]) and the position of the county in Scotland.

A: Westphalian coal measures; these extend west through Lanarkshire.

B: Millstone grit series; the source of fireclay

C: Carboniferous limestone series; formed of narrow bands of limestone and sandstone

shale fields are covered by superficial deposits of boulder clay, sand and gravel beds, and by extensive beds of peat in the south. The thickness of these deposits varies from a few metres to more than 20 metres thick [3, 7]. Later Carboniferous volcanic action caused intrusions of igneous rock that produced sufficient heat to distil kerogen out of the shale that condensed into small pockets of solid wax and liquid paraffin in cavities and fissures of the oil-shale beds at the boundaries with the intrusions [3]. The existence of oil had been known from these sources for centuries and there are records of an oil seep at Tar Hill near Ecclesmachan prior to 1791 [8]. There was no means of exploiting it effectively, however, although an industrial process to extract crude oil from shale was first patented in 1694 in Britain, and the first small-scale commercial plants were built in 1838 in France [9].

### Shale oil and “Paraffin” Young

In 1850 James “Paraffin” Young took out British patent number 13292 to register a new process for retorting and refining oil, and subsequently purifying paraffin wax from it [4]. He also registered a US patent effectively ensuring that he had world rights to the process.

James Young opened the original paraffin works in Bathgate, West Lothian using oil extracted from Cannel (parrot) coal. However, oil-bearing shale was discovered near Broxburn and West Calder in 1858, and Young discovered that paraffin oil was also extractable from this source. He patented the process of extracting the kerogen from shale and crude oil was retorted at Westwood and Winchburgh then refined at Pumpherston into the paraffin oil that earned him his nickname, “Paraffin” Young. The patent ran out in 1864 leading to a massive increase in the number of industrial workings and support industries linked to oil production [2, 3].

The refining processes were improved and developed during this period, and a second patent was taken out in 1865 (by Young's son) for an early version of the cracking process that is used by the modern oil industry. By this time there were already 120 oil works in operation in the West Lothian, each with their associated shale pits and mines, producing more than 100 million litres (~600,000 barrels) of crude oil every year. The oil works were run by at least 20 different companies, and employed 30-40,000 people [4, 10]. To put this into perspective, the total population of West Lothian in 1850 was 25,600 [11]. In 1866, Young's Paraffin Light and Mineral Oil Company Limited set up Addiewell works, the biggest oil works in the world. The oil-shale was supplied from seven shale mines. These works produced about 3.5 million litres of oil a year, occupied 28.3 ha of land and employed 1,500 workers [4]. Miners came into West Lothian from Ireland, Wales, Cornwall, the North of England and all parts of Scotland, as there was insufficient skilled labour available locally.

Although free-flowing oil had been discovered in Pennsylvania, U.S.A. by 1859 (and was refined using Young's patented process) it was some time before the imported oil was cheaper than the home manufactured product as the shale distillation process was now more efficient [12]. The industry in Scotland remained viable during this period because it also successfully utilised many of the waste materials from oil production to manufacture an extensive range of by-products.

Fluid to power lighthouses*	Ammonium sulphate fertiliser*
Detergent*	Combustable gas for lighting*
Naphtha*	Moth balls
Paraffin wax*	Candles
Wax for beekeepers*	Petroleum jelly*
Sulphuric acid	Paints
Rubber goods	Motor spirit (petrol)*
Diesel*	Bricks

All by-products listed were produced commercially in West Lothian; those denoted with an asterisk (\*) were produced during the retorting and refining processes and the others at local chemical works using by-products of the oil extraction process. Data extracted from [2, 3, 10, 13].

The maximum output from the shale industry was in 1913, when 3.5 million tons (27,125,000 barrels) of crude oil was produced. In 1925 there were 25 working shale mines in West Lothian but from then there was a gradual reduction in operations due to competition, initially from the Persian oilfields. By 1951 output was reduced to only 1.5 million tons (11,625,000 barrels) and by 1958 only 7 mines and 2 opencast workings remained in operation (the latter were in the process of closing), although the industry still employed 2,850 men. Production ceased in 1962 when preferential tax treatment [12] was withdrawn; the last working mine was at Westwood [2, 10]. The Pumpherston refinery was all that remained of the original Scottish shale oil industry. Ironically when it closed in 1993 it was producing the detergent used to disperse oil spillages from the North Sea oilfields [4].

### Scotland's oil industry today

It has been estimated that 300 million tonnes of oil shale remain commercially extractable from the Scottish oilfield [14] although the environmental consequences of extraction make their exploitation unlikely.

When the British Petroleum company struck oil in the North Sea in 1970 a new era in Scotland's oil industry began, employing 9,000 men (5,000 working offshore) in 1989. Up to 400,000 barrels of oil a day are currently refined at Grangemouth, one of the largest and most integrated oil and gas complexes in the world, and stored in tanks buried deep under Dalmeny bing before being shipped from the oil terminal at Hound Point [15].

Over one hundred and fifty years of industrialisation in West Lothian and the Scottish oil industry are thus directly attributable to one man, James Young, his development of an industrial process to extract crude oil from deep mined oil-bearing shale and the coincidence of a series of geological events.

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