Exploration in the UK Weald Basin: Déjà Vu*

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Introduction and Early History

Geological investigations in the Weald area of southeast England (Figure 1) have occurred for the past two centuries, but recently there has been a flurry of speculation, particularly in the popular press, over the possibility of the Weald basin becoming a major hydrocarbon province with billions of barrels of oil in place. Over 120 years ago there was similar excitement concerning the discovery of natural gas at Heathfield, in the heart of the Weald.

The first serious attempt to show the general structure of the Weald was by John Farey in 1806; a manuscript copy of his 1807 geological section is reproduced in Figure 2 (A-A'). The section follows the line of the London to Brighton toll road, and apparently was the result of "traveling notes" made during three coach journeys up and down the road. The section was drawn at a horizontal scale of one inch to a mile and can be accurately located from milestones shown on the section.

Farey clearly shows the anticlinal (his term was "strata-ridge") nature of the Weald and also the denudation of the Chalk and subsequent un-roofing of the anticline. He also was the first geologist to demonstrate the importance of faults in the region. Although incorrect in some details, and given that Farey had no knowledge of the deep structure, the section is still a remarkable achievement. However, Farey at that time was subjected to a number of scathing attacks from the geological establishment. Particularly, Robert Bakewell wrote in 1813:
"I confess I do not set a high value on this kind of 'stage-coach geology': It may account, however, for some extraordinary descriptions which have of late years been given to the public."

Farey was a pupil of the great William Smith, and a decade after Farey's section, Smith mapped the Weald and, in 1819, published a "Vertical Section of Surry [sic] dipping northward. Section in Sussex dipping southward." Although Smith shows the anticlinal nature of the Weald, he would not have understood the reason for it. Unlike Farey, he was more concerned with the ordering of the strata and had little appreciation of the importance of faulting and structure. Smith's problem with the Weald was that he was unaware of a thick section, which we now know to

be of Early Cretaceous age, between the base of the Gault and the top of the Jurassic. Elsewhere in the country he was used to the Gault resting directly upon his Purbeck and Portland rocks, and this led to his misinterpretation of Wealden sandstones and clays as Jurassic, rather than Cretaceous.

Farey and Smith's early work was followed by more detailed studies; of note was that of Gideon Mantell, a medical doctor from Lewes. Working in the central part of the Weald, Mantell suggested that the strata may be freshwater in origin. He is renowned for the discovery of the dinosaur, *Iguanodon* (which was named by him).

Further work was conducted by a number of geological luminaries, including W.H. Fitton, Thomas Webster, Sir Roderick Murchison, and Sir Charles Lyell. The Geological Survey commenced work in the Weald in 1855. In 1875 William Topley incorporated its early work into the Memoir of the Geological Survey, titled "The Geology of the Weald."

Based on the results from later deep borings, it became apparent that there was a considerable thickness of Mesozoic sediments in the Weald, and it was indeed a basin. As a result of Alpine movements the basin was inverted and unroofed. The composite seismic section from AAPG member Malcolm Butler and Rachel Jamieson (UKOGL, 2013) shown in Figure 2 (C-C') gives a good impression of the basin's structure.

Mantell, writing in 1822, first described hydrocarbons in highly bituminous sandstone at Chilley near Pevensey; oil seeps were subsequently recorded at the same location. In 1836, two laborers sinking a water well to the north at Hawkshurst encountered gas, which was ignited by a lantern – and, unfortunately, resulted in their deaths.

Sub-Wealden Exploration

In 1872 a remarkable project, the Sub-Wealden Exploration – an academic endeavor funded by the scientific community, including Charles Darwin and family – was undertaken to discover what lay beneath the Weald's exposed strata. The project had no stated commercial objective, although popular opinion was that it was intended to search for coal. Indeed, Godwin-Austen had previously suggested that Carboniferous Coal Measures may exist below the Weald.

The exploration committee had an enthusiastic and ever-optimistic secretary, Henry Willett, who documented the entire venture up to completion in 1877. The bore site was near Netherfield in East Sussex (Figure 3). Initial boring was done by the then-conventional percussive "jumper" method, but this was found to be too slow and laborious and was soon replaced by rotary diamond drilling, which was considerably faster and could produce good core.

After drilling a Purbeck section containing thick-bedded gypsum underlain by Portland sandstone, an extremely thick Kimmeridgian section was encountered. At 450 feet there were abundant oil shows from highly bituminous zones, which showed a paucity of fossils. Due to drilling difficulties the initial bore was abandoned at 1018 feet, and a new bore started nearby.

Oil and gas shows were again plentiful in the second bore, and at ,640 feet there was a significant gas discharge and an explosion. All concerned were keen to progress through the Kimmeridge Clay and to discover the Paleozoic floor. This, alas, was not to be, as the Kimmeridge Clay proved to be too thick, and funds for continued drilling were unavailable.

At the time of the sub-Wealden exploration there was little interest in the oil and gas present in the Kimmeridge clay. However, today these historical indications, together with the recorded intercalated micritic limestones within the shales are extremely relevant to the possible existence of extensive unconventional resources in the Weald basin. It was not until 1890 that the Paleozoic was reached by boring near Dover. Coal measures were encountered, which eventually led to the development of the concealed Kent coalfield.

A major issue today concerns the environmental impact of drilling – particularly hydraulic fracturing – in the Weald, which has been designated as an area of outstanding natural beauty.

At the time of the sub-Wealden exploration, it was locally thought that the operation was intended to produce coal, and Henry Willett in his second Quarterly Report noted, "some persons already see in imagination, the beautiful country around Battle 'black' with grime and soot." Nearly 20 years after the sub-Wealden exploration an accidental gas discovery was made to the west at Heathfield (Figure 3) during the drilling of a deep artesian well. At 228 feet the foreman noticed that the drilling water in the well appeared to be "boiling." A candle lowered to investigate the phenomenon caused bubbling gas to ignite and the flare-out of the well.

A year later, another well sunk by the local railway company near the railway station again encountered gas, this time at 312 feet, and the gas (produced at 1000 cubic feet/day) was subsequently used to light the railway station and some 70-80 adjacent houses, as well as supply power for several gas engines. At this time a failed ruby miner, named Richard Pearson, appeared on the scene, and together with a number of American investors established Natural Gas Fields of England Ltd. in 1901, with Pearson being managing director. With high hopes, the company drilled six more wells, all of which apparently encountered gas, albeit in undisclosed quantities. "Borings are now being made over some 200 square miles in the county of Sussex," Pearson wrote, "and the writer soon hopes to prove large supplies of gas throughout this territory."

A medal was struck in 1902 celebrating the Heathfield natural gas field, and Pearson negotiated with the railway company to lay pipe along its railway track to connect larger towns to the discovery. Dreams of a huge discovery, however, were soon to fade; the company went into liquidation in 1904, and Pearson then went on to float South Australian Petroleum Fields Ltd. and try his luck in Australia.

Even so, rumors of a significant Wealden gas belt persisted into the 1930s. A small number of wells were drilled in the Weald, both before and immediately after World War II. Although some oil and gas was found, it was considered to be noncommercial.

An interesting aside to the Heathfield gas story is that early accounts of the discovery written in Nature and the Quarterly Journal of the Geological Society of London were by Charles Dawson, who later was to "discover" the remains of Piltdown man, an evolutionary missing link between man and apes. The discovery was subsequently proved to be possibly the greatest hoax in the history of science – and Charles Dawson remains the prime suspect.

Recent History

Following the 1973 OPEC oil embargo, there was a sharp rise in onshore UK exploration – including the Weald basin, which reached a peak in 1986, when 26 wells were drilled. Discoveries, mostly in the Jurassic, were made, but were generally small.

Recently, however, amid the heated debate on the merits of hydraulic fracturing in the United Kingdom, there has been renewed commercial interest in the Weald; the operator of the Balcombe-2 well has targeted micrites within the Kimmeridge Clay and has confirmed the presence of hydrocarbons.

Most recently, a well drilled north of Gatwick Airport at Horse Hill (Figure 4) was reported to have discovered 14-22 MMBO in a conventional Portland sandstone play, and 115 MMBO from naturally fractured hybrid micrites reservoirs within a thick Kimmeridge Clay sequence. This has given rise to great excitement in the press with talk of the so-called "Gatwick Gusher."

A recent British Geological Survey report on resource estimation of Jurassic shales, however, is less optimistic. BGS estimates that all Jurassic shales in the Weald contain between 2.2 and 8.6 billion barrels of oil in place. A realistic evaluation of shale-oil resources probably will be achievable only after extensive drilling and testing.

The source of gas in the Weald basin is problematic; it is generally thought that Jurassic shales are not mature enough to be within the dry-gas window. Gas present may have been coeval with oil generated within the oil window, then exsolved at shallow depth after uplift. Alternatively, the gas may have come from deeper sources.

In oil and gas exploration, as indeed in many aspects of modern-day life, there are always analogies and valuable lessons to be learned from history.

Selected Reference

Butler, M., and R. Jamieson, 2013, Preliminary interpretation of six regional profiles across onshore basins of England: UK Onshore Geophysical Library, http://maps.lynxinfo.co.uk/docs/images/interpretations.

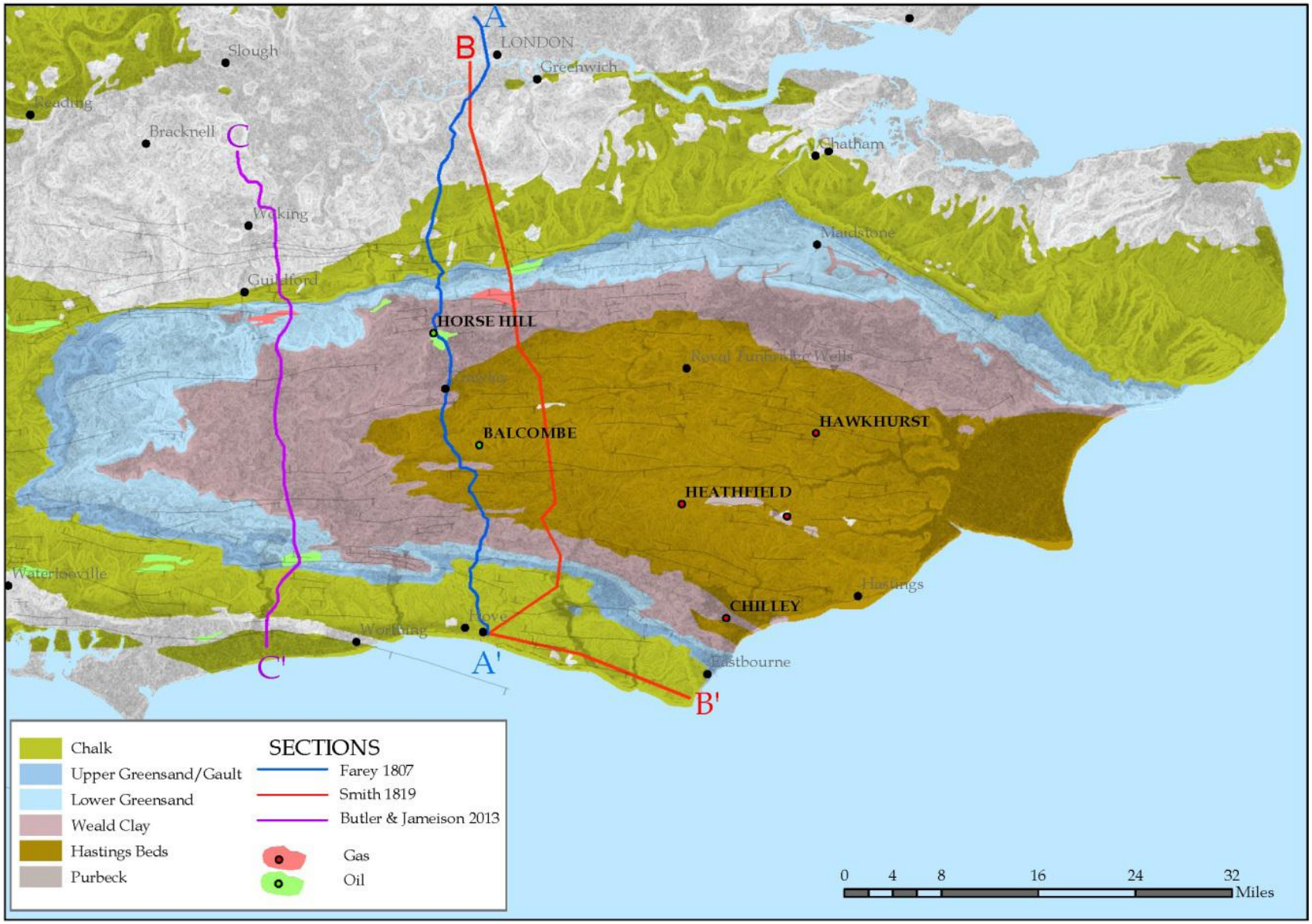

Figure 1. Location map of the Weald area of southeastern UK showing oil and gas discoveries, geology and the locations of cross-sections given in Figure 2.

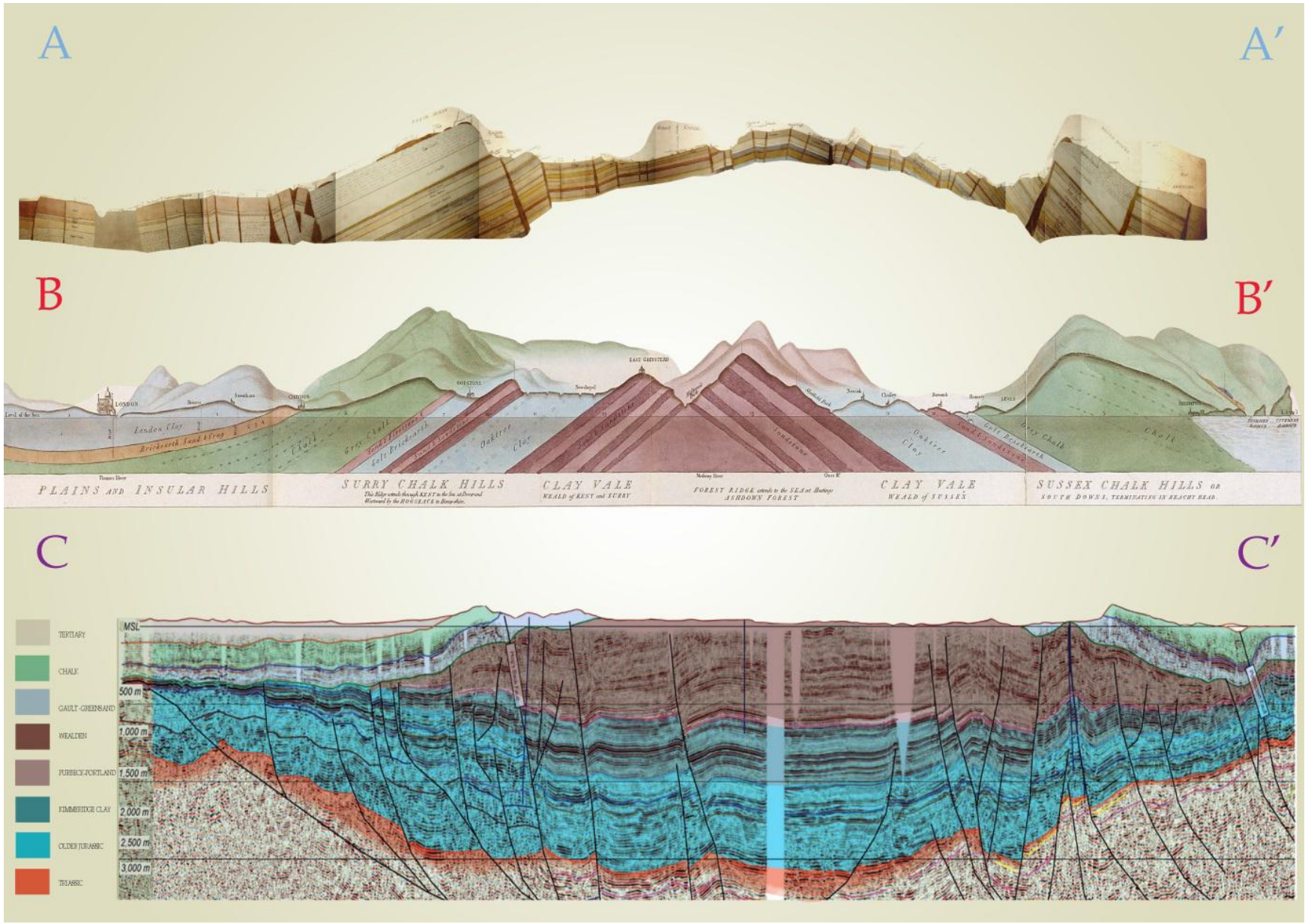

Figure 2. Geological cross-sections of the Weald by John Farey, A-A' (1807), William Smith, B-B' (1819), and an interpreted composite seismic section, C-C', modified from Butler and Jamieson (2013). John Farey section courtesy of Hugh Torrens.

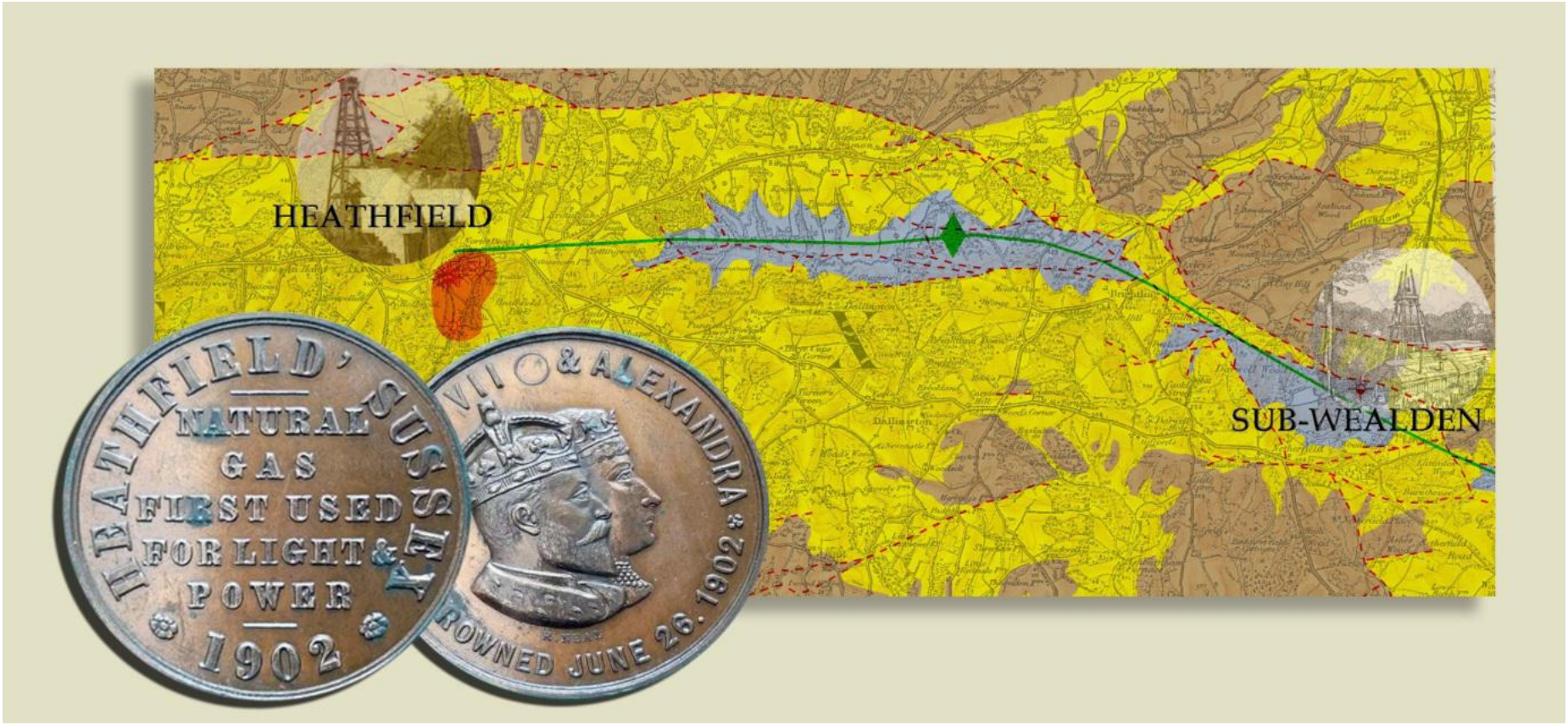

Figure 3. Location of the sub-Wealden exploration and Heathfield gas field. Purbeck beds (light blue) are exposed in the core of the anticline. The 1902 medal commemorated the natural gas discovery.

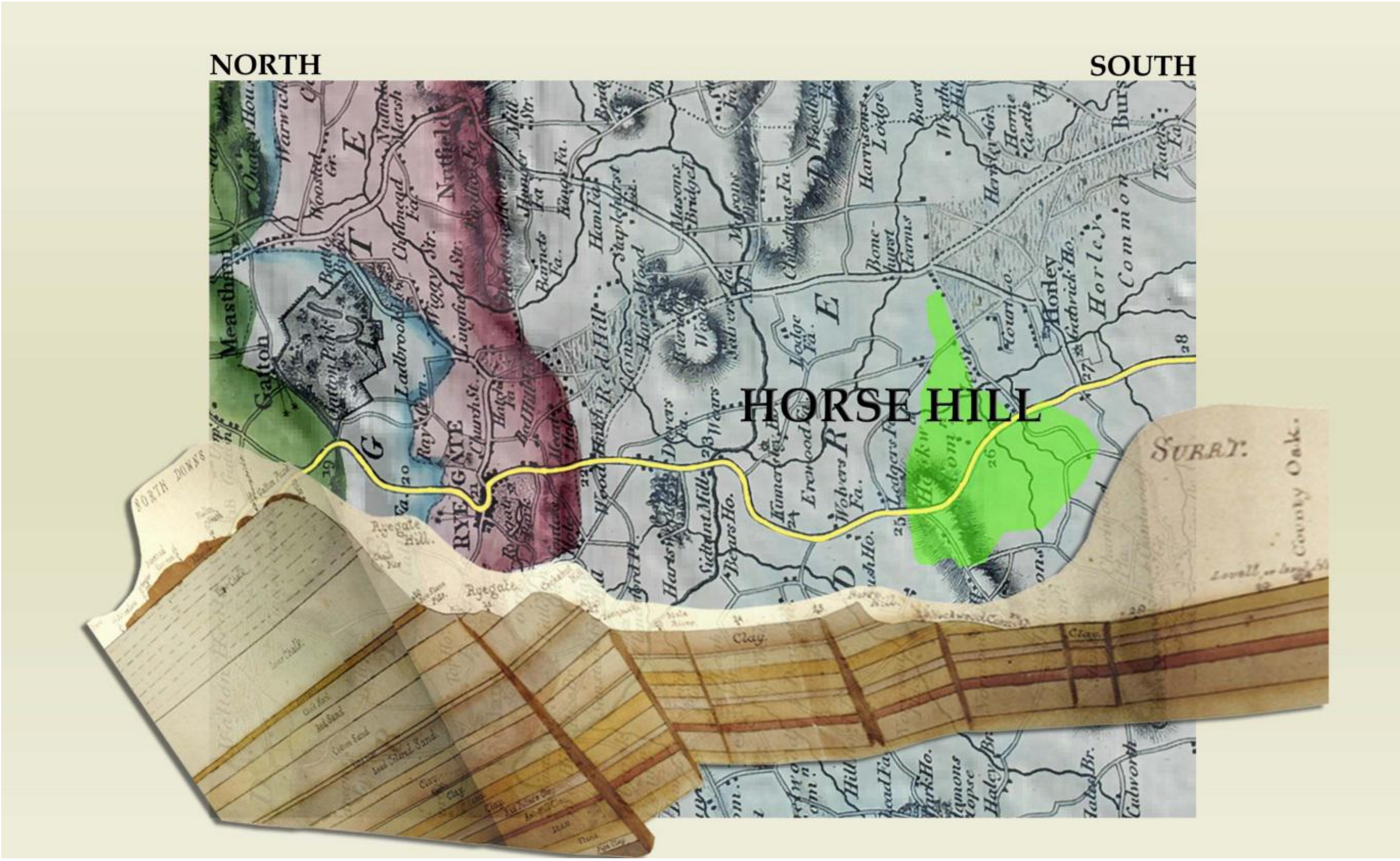

Figure 4. Location of the Horse Hill oil discovery close to Gatwick Airport overlain on William Smith's 1819 Geological Map of "Surry," together with part of John Farey's 1807 N-S geological cross-section. Note the location of Horse Hill on the London-Brighton toll road (yellow) between milestones 25 and 26.