**Digging Deeper: The influence of historic mining on Glasgow’s subsurface thermal state to inform geothermal research**

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**Supplementary Information**

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**1. Chronology of mining at each borehole location**

This section details the timing, duration and proximity of mineral prospecting and extraction at each of the borehole locations to investigate the influence of the presence of mine-workings on existing borehole temperature and heat flow measurements in Glasgow.

*Blythswood - 1*

Blackband Ironstone and Clayband Ironstone were extensively mined on the Blythswood Estate in the mid to late 19th century. Shown in Fig. 5 at Portnauld, west of the Black Cart Water, the Blackband Ironstone seam was worked from shallow pits. East of the Black Cart Water, it was mined at a greater depth over a small area from the chief pit, No. 4 Pit Blythswood. This pit, 148 m deep, was situated in the grounds of Blythswood House (Hinxman *et al.* 1920; MacGregor *et al.* 1920), in close proximity to the Blythswood - 1 bore.

The earliest record found regarding mining taking place on the Blythswood Estate is dated from 28th July 1866, when a serious pit accident occurred at the No.1 Pit on Portnauld Farm (Paisley Herald and Renfewshire Advertiser 1866). The article states that this was one of several pits opened, or in the course of being opened, by the Langloan Iron Company (owned by R. Addie and Sons) on the estate of Mr. Campbell of Blythswood.

On the grounds of Blythswood House, the earliest records found relating to mineral exploration are prospecting borehole logs dated from 1863. Many of the logs refer to the fact that they were sunk on behalf of Robert Addie and Sons, the coal master of the ironstone workings on Blythswood Estate (Addie 1874, 1875) and highlight seams of coal, ironstone, Clayband Ironstone and Blackband Ironstone when encountered.

Further to this, information on the prospecting of minerals on the Blythswood Estate was obtained from Item TD234/85 of the Glasgow Archive. There are a number of letters written by Professor Denny of the Andersonian Institute (now Strathclyde University) relating to chemical reports on samples from ironstone borings on the Blythswood Estate. The letters contain the results of a chemical analysis on the borehole samples, with the objective being to evaluate the quality of the ironstone and the composition of the samples. The letters are dated from October 1864. In one such letter, Professor Denny states that apart from 1 sample (out of 7 analysed) all borings are Blackband Ironstone, with 1 sample being Clayband Ironstone. This suggests that preliminary tests were being conducted in the early 1860’s, until 1864/65, with pits being sunk and workings extended in the subsequent years.

Based upon Item TD234/54/3 of the Glasgow Archive, Fig. 6 illustrates the timing and extent of mining on the Blythswood Estate east of the Black Cart Water. The No. 4 Pit and related workings are dated; 09/12/1868, 12/05/1869, and 30/12/1869. The Blythswood - 1 bore is also noted on the plan, with workings dated from 30/12/1869 extending to this location. Table 5 shows that the Blythswood mine was abandoned on the 26th of April 1875 (Home Department 1889; Mines Department 1931).

The chronology of mining on the Blythswood Estate can be established. From the early to mid-1860’s exploratory boreholes were sunk to prospect for Blackband and Clayband Ironstone. The first record of mining on the Estate dates from 1866 at No. 1 Pit at Portnauld, west of the Black Cart Water. From 1867 to 1870, ironstone workings were developed from No. 1, No. 3 and No. 5 Pits at Portnauld. Lord Kelvin conducted subsurface temperature observations at Blythswood - 1 bore from December 1867 to January 1868 (Thomson *et al.* 1869). From December 1868 to December 1869, workings were developed from No. 4 Pit east of the Black Cart Water, extending close to the Blythswood - 1 bore. On the 26th of April 1875 the Blythswood ironstone workings were abandoned. Based upon this, the measurements made by Lord Kelvin would not have been influenced by the effect of mine workings close to the Blythswood - 1 bore and are therefore a good approximation for the undisturbed thermal state.

*South Balgray*

The South Balgray borehole was drilled in 1864 to 320 m depth, temperature observations being conducted by Sir William Thomson in 1869 (Thomson *et al.* 1869). The borehole log indicates that it was drilled through the Limestone Coal Formation and the Lower Limestone Group, into the Lawmuir Formation (Fig. 2). The purpose of this boring was to prospect for seams of coal and ironstone with the Balgray-Gartnavel field. Previously published reports of temperature and heat flow data for the Midland Valley have stated the location of the South Balgray borehole as NS 50 75, placing the borehole within the range of the Kilpatrick Hills. By consulting historic maps (Fig. S1), South Balgray farm existed in the present-day location of Hyndland, western Glasgow. The No. 3 Gartnavel borehole is located at the site of the South Balgray farm at NS 55780 67810, (BGS Reference NS56NE369). The depth and stratigraphy of the No. 3 Gartnavel borehole is consistent with that reported in Thomson *et al.* (1868, 1869) for the South Balgray borehole. It can be reasonably assumed that the No. 3 Gartnavel borehole is that referred to as South Balgray in Thomson *et al.* (1868, 1869) and all subsequent publications.

The South Balgray borehole is located to the south of the Gartnavel-Balgray and Garscube mineral fields. As well as the ironstone pits at Blythswood Estate, the coalmaster of Balgray Colliery was Robert Addie and Sons (National Records of Scotland 1872). There are numerous pits within the Gartnavel-Balgray field sunk to Gas Coal, Blackband Ironstone and Clayband Ironstone (Fig. 7; Table 5).

Garscadden ironstone was formerly one of the chief sources of ironstone in the west of Scotland. The Lower Garscadden Blackband and Upper Garscadden Blackband ironstones were raised over a considerable area at Jordanhill, Skaterigg, Garscube and Gartnavel until 1896. Similarly, Garibaldi Clayband ironstone was raised up to the year of 1892 across this area (Hinxman *et al.* 1920). California Clayband ironstone was worked for a considerable period around the middle of the 19th century, in the neighbourhood of Gartnavel and at a later date a small area was opened up at Garscube (Hinxman *et al.* 1920).

Extensive mining north of the South Balgray borehole took place prior to the date on which temperature measurements were made (Table 5; Fig. 8). At various pits at Gartnavel, coal and ironstone were worked until abandonment in 1874. Of particular relevance is the entry for Gartnavel No.5 and No. 6 which states that Garibaldi and Blackband Ironstone were worked in 1869. The entry for Balgray states that Blackband Ironstone was worked in 1866. For Balgray and Gartnavel Pits, seams of coal and ironstone were worked till abandonment in 1880.

National Records of Scotland Item RHP145001/36/23326, is a plan of the various mine workings in the Gartnavel-Balgray field. This item details the target coal and ironstone seams, extent of each of the workings and the date at which mining took place. The locations of the key pits shown in this item in relation to the location of the South Balgray borehole is summarised in Fig. 8.

National Records of Scotland Item RHP145001/36/23326 illustrates that the workings closest to South Balgray borehole at North Balgray Farm are Clayband Ironstone workings. Garibaldi Clayband, or Upper and Lower Garscadden Blackband Ironstone are the most likely seams to have been worked in close proximity to the South Balgray borehole. The workings extending from Gartnavel No. 6 are dated 25th July 1865 and 14th December 1869. The earliest workings in this area between Balgray Farm and West Balgray House are Gas Coal workings dated 22nd March 1864. The Blackband Ironstone workings are dated 1866.

Shown on Fig. 2, the South Balgray borehole encountered the Lower Garscadden Ironstone at a depth of ~18 m and the Garibaldi Clayband Ironstone at a depth of ~22 m. The Upper Garscadden Ironstone and California Ironstone were not encountered in the South Balgray borehole, lying stratigraphically above the surface geology at the site.

A borehole entitled No. 1 Pit Balgray at NS 55975 68550 and BGS Reference NS56NE82 encountered the Upper Garscadden Ironstone at a depth of ~48 m, the Lower Garscadden at a depth of around ~73 m and the Garibaldi Clayband at around ~84 m depth. This borehole is around a kilometre to the north of the South Balgray borehole. Workings of these seams closer to the South Balgray borehole would have existed at shallower depths than those encountered in the No. 1 Pit Balgray bore.

The temperature observations in the South Balgray borehole were recorded by Lord Kelvin at the same time as mining activity took place in the Gartnavel-Balgray mineral field. However, based upon the plan of workings in the Gartnavel-Balgray field, the South Balgray borehole lies out with the extent of the workings. Further, those seams worked in the Gartnavel-Balgray field lie at relatively shallow depth within the South Balgray borehole. It may therefore be reasonably concluded that the temperature measurements were not influenced by mining and are a good approximation for the undisturbed thermal state.

*Queenslie - 4*

Extensive coal mining activity took place at Queenslie and the surrounding areas of Shettleston and Garthamlock in the East End of Glasgow through the 19th century and into the early 20th century.

Illustrated in Fig. 9, the two prominent collieries and associated mine shafts in the area of the Queenslie - 4 borehole are Queenslie Colliery and Garthamlock Colliery. Detailed in Table 4, both collieries ceased operation in 1935, around two decades prior to the drilling of the Queenslie - 4 borehole. This was drilled to a depth of 732.58 m and the temperature was measured at 691 m below ground level (Table 2). The first 441 m of the borehole was not cored and is described in the borehole log as “open hole”. This section of the borehole contains coal seams mined in the locality. Table 5 shows that at Queenslie Colliery, Virgin and Virtuewell Coal were worked. The Queenslie - 4 borehole encounters the Virgin Coal seam at a depth of ~64 m, and while there is no note within the log of the Virtuewell seam, this would lie between 64 m and the Kiltongue Coal at ~134 m depth (Fig. 2). This borehole is located on the site of former Cranhill Quarry [NS 64900 65930] and in close proximity to Cranhill Fireclay works [NS 65060 65920]. The associated industrial processes at these works may have caused additional warming of the shallow subsurface. This shall be studied in future work.

The Queenslie - 4 borehole is located in an area of Glasgow with an extensive history of mining which took place prior to the date at which the borehole was drilled, and the temperature measured. While the extent of the mine workings associated to the pits at Garthamlock and Queenslie are unknown, examination of historical maps places the borehole some distance from former shafts. The seams of coal worked in this area lay between ~64 and ~134 m in the Queenslie - 4 borehole. Given that only one temperature measurement was recorded in the borehole at 691 m depth, no conclusion can be drawn on whether the geothermal gradient in the top ~134 m of the borehole is perturbed by mine-workings. However, the temperature measurement at 691 m can be considered a good approximation for the undisturbed thermal state at this depth.

*Hallside*

Hallside Village was originally built to serve the nearby Hallside Colliery and expanded in the early 1870’s to serve the Hallside Steelworks (Hall 2012). The Hallside Steelworks opened in 1872 when Sir Charles Tennant of the Saint Rollox Chemical Works founded the Steel Company of Scotland with 28 shareholders all connected with heavy engineering or chemical industries (Shephard, 1996). The site was chosen for its supply of water from the nearby River Clyde and the proximity of iron and coal deposits, all within easy reach by the rail network located adjacent to the site and latterly directly to the site (Shephard, 1996). The Hallside Steelworks was one of the major steel producing centres in Scotland until its closure in 1979 (Shephard, 1996). Hallside Colliery opened in 1873 and closed in 1921 (Mines Department 1931).

The Hallside borehole is located on the site of the former Hallside Colliery (Fig. 10). From Table 5, Hallside Colliery worked seams of Upper Coal, Ell Coal, Pyotshaw Coal, Main Coal, Splint Coal and Virgin Coal.

By consulting archive records of the National Coal Board at the National Records of Scotland (Item CB 475) there were various pits active in the 1960’s at Hallside. Those pits which remained active at this time were Blantyreferme 1 & 2, and Blantyreferme 3. It’s stated that these pits were working the Virtuewell, Lower Drumgray and Blackband seams. Blantyreferme 1 & 2 closed in 1962 and Blantyreferme 3 in 1964 (Oglethorpe 2006).

National Records of Scotland item CB 475/50/8, shows the extent and timescale in which each seam of coal was worked at the Hallside and Blantyreferme pits. The plans show; Main Coal workings dated 01/1890 and 01/1892, Virgin Coal workings dated 04/10/1910, Pyotshaw workings dated 18/01/1915, Humph Coal workings dated 04/1920, Upper Coal workings dated 17/06/1932 and Ell Coal workings dated 21/03/1944. The depths of the worked seams are shown in Fig. 11. All but a few of the plans show worked seams which are either in close proximity to or lie directly beneath the location of the Hallside borehole.

In the Hallside Borehole, the base of the Upper Coal Measures was encountered at ~279 m depth, with the borehole terminating at a depth of ~352 m (Fig. 2). Another borehole, named the “Hallside Colliery” borehole, was sunk from ~265 m depth to a depth of ~451 m to give a section of the stratigraphy at the colliery. It is assumed that the depth of each seam is the same in the “Hallside Colliery” borehole as in the Hallside borehole (Fig. 11). Clough *et al.* (1920) state that at Hallside Colliery, the Middle Coal Measures were overlain by around 293 m of Upper Coal Measures. This aligns relatively well with the boundary of the Upper Coal and Middle Coal Measures observed in the Hallside borehole (Fig. 11), indicating that there is indeed close alignment between the depths of seams in the Hallside borehole and those worked in the Hallside Colliery.

Given the proximity of the Hallside borehole to steelworks (Ordnance Survey, 1914b), related industrial processes may have an influence on the downward propagation of heat conduction from the surface to the shallow subsurface (cf. Westaway & Younger, 2016). Assessment of this effect is beyond the scope of the current study, but will it be explored in future work.

In summary, the Hallside borehole is located on the site of the former Hallside Colliery and within the extent of mine workings associated with Hallside Steelworks. Extensive mining activity had taken place at this site prior to the drilling of the Hallside borehole and the measurement of temperature therein. The seams worked were deeper than the base of the Hallside borehole and of the deepest temperature measurement. This evidence suggests that there may be a potential influence from this legacy of mining on the flow of heat in the subsurface and is perhaps a contributing factor as to why a low bottom hole temperature and associated heat flow, was observed in the Hallside borehole.

*Hurlet*

The village of Hurlet began as a small mining community on the Hawkhead Estate, owned by the Earls of Glasgow. The village grew rapidly as a result of early 19th century industrial development where coal and building stone were supplied by canal and railway to the city of Glasgow (Smart 1996).

At Hurlet, coal, ironstone, limestone and alum shales were all extracted from the subsurface. The working area was considerable, with miles of passages and numerous shafts (Skillen 1990). By the 1830’s limestone was mined at Hurlet from pits up to 70 m deep (Dron 1902; Nisbet 2005). In Hinxman *et al.* (1920), it states that Hurlet Limestone can be seen at Hurlet, at the mouth of an old mine inside the wood about 400 yards south of West Hurlet House. The Hurlet Coal seam extended over about 500 acres of land on the Hawkhead (Hurlet), Househill and Nether Pollock Estates (Smart 1996) and was worked from various pits either side of the village of Hurlet (Hinxman *et al.* 1920). The most valuable Clayband Ironstone’s of the Lower Limestone Group are the Househill Clayband’s. They were formerly worked from several pits along the Levern Water to the east of Hurlet (MacGregor *et al.* 1920).

The extent of the mining activity in the village of Hurlet is shown on Fig. 4, with numerous pits dotted throughout the area. The areas of the Hurlet Coal shown to have been worked are south west of the outcrop from the village of Hurlet (Hinxman *et al.* 1920). The lands of West Hurlet House, and the location of the Hurlet borehole, lie north east of the outcrop of the Hurlet Coal, and out with the area in which the coal was wrought. This is evident by assessing the stratigraphy of the Hurlet borehole (Fig. 2). The Hurlet borehole is drilled through a sequence of the Lawmuir Formation, stratigraphically below the Hurlet Coal seam and other worked seams in the Lower Limestone Group.

It is therefore unlikely that coal, ironstone or limestone were worked at significant depth in the vicinity of the Hurlet Borehole on the grounds of West Hurlet House. However, surface and/or shallow mining for Hurlet Coal, Househill Clayband or Hurlet Limestone, may have taken place close to the location of the Hurlet Borehole. Data available from Oxburgh (1982) are limited to a depth range of 95-295 m and the influence of potential surface/shallow workings cannot be observed. These data can be considered a good approximation for the undisturbed thermal state across the measured depth range.

*Maryhill*

The Maryhill borehole is located to the east of the Gartnavel-Balgray, Jordanhill-Skatergigg and Garscube fields, separated from these fields by the River Kelvin and the Forth and Clyde Canal (Fig. 12).

On a similar note to the development of Hallside Steelworks, given its proximity to key railway links and the ironstone pits of the Lanarkshire Basin, the iron and steel industry flourished in north Glasgow. This is particularly the case for Maryhill. The Maryhill borehole is situated ~100 m from the site of the former Maryhill Ironworks (Fig. S3). Established in 1877, the Maryhill Ironworks comprised of numerous foundries and workshops. Advantageously situated on the Forth and Clyde Canal, a railway siding ran into the works, facilitating the transport to and from the works of raw material and manufactured goods. By assessment of historic Ordnance Survey maps of the area, the Ironworks operated until the mid 20th century. While outside the scope of this present study, this is relevant as the Maryhill borehole is located directly on the railway siding leading into the site of the former Maryhill Ironworks. The terrain at this site has been altered due to the construction of the siding and the elevation (amsl) reported in Burley et al (1984) for the borehole appears innacurate. This has been corrected in Table 2. Further, as with Hallside, the industrial processes involved at the Maryhill Ironworks may have an influence on the downward propagation of heat from the surface to the shallow subsurface as in (Westaway & Younger, 2016). This shall be studied in future work.

Table 5 details mining activity around the area of Maryhill. The Garibaldi and California Clayband ironstones were worked at Ruchill 4 and 6 pits, east of the Maryhill borehole (Fig. 12). South of the Maryhill borehole and east of Balgray-Gartnavel field, the Garibaldi Clayband Ironstone was raised from several pits in the Eastpark district of Maryhill (MacGregor *et al.* 1920). The extent of the workings is relatively unknown given that at the time of writing of MacGregor *et al.* (1920), urban development of this area of Glasgow had resulted in much of the ground being almost completely built over.

The Garibaldi Clayband Ironstone seam was encountered at a depth of ~16 m in the Maryhill borehole (Fig. 2). The California Ironstone lies above the Garibaldi Clayband Ironstone in the stratigraphy of this area. It would therefore appear that the California Clayband Ironstone seam was not encountered in the Maryhill borehole.

The Kilsyth Coking Coal was encountered at ~26 m depth in the Maryhill borehole (Fig. 2). Hinxman *et al.* (1920) stated that this was the lowest workable seam in the Limestone Coal Formation. The Maryhill borehole is located in an area of Glasgow with a history of mining prior to the drilling of the borehole. While the extent of the mine workings at Eastpark are unknown, the seams of coal worked in this area of Glasgow lay at shallow depth relative to the borehole. From examination of the geothermal gradient in the shallow ~30 m of the borehole, it is unclear as to whether shallow mine-workings have disturbed the thermal state. Additional factors such as the downward propagation of heat from the Maryhill Ironworks may counteract the dispersion of heat flow locally into mine-workings. However, the temperature measurements made below 30 m depth, appear to be a good approximation for the undisturbed thermal state at this site.

*Bargeddie - 1*

The Bargeddie - 1 borehole is drilled in an area known to have been extensively mined for coal throughout the 19th century (Table 5). This borehole is located close to a number of mine shafts related to the Bargeddie and Bartonshill collieries (Fig. 13). From the drilling report, a relatively complete section of Middle and Lower Coal Measures was encountered. Within the Middle and Lower Coal Measures, to a depth of 293 m, four coals are known to have been worked at the site, the Upper, Main, Splint and Kiltongue seams (IHS Energy Group No Date). This is consistent with Table 5.

The Cuilhill Bore (Fig. 13), drilled to a depth of ~757 m (BGS Reference: NS76NW345), was used to exert control on the understanding of the subsurface prior to drilling the Bargeddie - 1 bore. If this borehole is to be used as analogous to Bargeddie - 1, then the position of the seams stated in the Cuilhill borehole can be used to assess the depth of workings close to the Bargeddie - 1 borehole. The Cuilhill bore encountered the Main Coal at 50 m, the Splint Coal at 70 m, the Virgin Coal at 72 m and the Kiltongue Coal at 150 m. Shallower seams of Glasgow Upper and Pyotshaw Coal were not encountered, the shallowest seam encountered being the Glasgow Ell Coal. As shown in Fig. 13, numerous shafts surround the location of the Bargeddie - 1 borehole. It may thus be expected that the geothermal gradient may be perturbed in the borehole by the presence of these mine-workings. However, given the lack of temperature data across this depth range, no conclusion can be drawn on the potential influence of mining at Bargeddie. The bottom hole temperature measurement made in the Bargeddie - 1 borehole of 39 °C at 1043.6 m is well below the potential influence of mine workings and can be considered a good approximation for the undisturbed thermal state at this depth.

*GGC01*

Work at the GGERFS aims to investigate the abandoned, flooded mine workings beneath the Clyde Gateway Regeneration area of Glasgow. The GGC01 borehole is the deepest of twelve boreholes drilled in the Clyde Gateway area of Dalmarnock, Glasgow as part of the GGERFS project. Its main purpose is to host seismometers for monitoring earthquake activity including the possibility of earthquakes caused by activity at the GGERFS site.

By 1860, Dalmarnock contained an ironworks, gasworks, colliery, sewage works and power station. The extent of mining in this locality has been summarised by Monaghan *et al.* (2017) and Monaghan *et al.* (2018). There are seven worked coal seams, with related shafts and interconnecting underground roadways, beneath the area within which the 12 GGERFS boreholes are located (Monaghan *et al.* 2017; Monaghan *et al*. 2018). The deepest worked seam beneath this area is the Kiltongue Coal seam, however the depth of this seam varies laterally throughout the area. At its deepest it is encountered at 268.5 m depth (Monaghan *et al.* 2017). At the site of the GGC01 borehole it is predicted to be shallower that this, at around 225 m depth (Monaghan *et al.* 2017).

There are no recorded mine workings on abandonment plans at the site of the GGC01 borehole. After drilling the borehole, it was confirmed that no evidence of mining was encountered in the borehole and several thick intact coals were cored (Starcher *et al.* 2019).

However, to the east of the GGC01 borehole there is extensive coverage of mine workings beneath the GGERFS area. Given the presence of these recorded mine workings, it is considered possible that there are unrecorded mine workings. Indeed, the Northern Mine Research Society Interactive Map states that Dalmarnock Colliery (261175, 662710), owned by George Wilson, mined coal from 1854-1855. The Coal Authority Interactive Map displays records of mine entries and working dates from 1830 onwards through until the 20th century in addition to areas of “probable workings” beneath the site of the GGC01 borehole. Further to this, as previously stated, Monaghan *et al.* (2017) and Monaghan *et al.* (2018) state that abandonment plans dating from as early as 1810 were consulted. Mining activity in this area of Glasgow took place prior to the 1872 Regulation of Coal Mines Act which legislated that accurate mine abandonment plans must be recorded in compliance with the act. It is therefore possible that unrecorded mine workings exist beneath the site of the GGC01 borehole.

From the preliminary driller’s log, the deepest coal seam in the GGC01 borehole is thought to be the Airdrie Virtuewell Coal at 197 m depth (Barron & Burkin 2019). However, the mined Kiltongue Coal seam is deeper; Kearsey et al. (2018) estimate it to lie 31 m below the Virtuewell seam, on which basis we estimate its depth as 228 m (Fig. 14).

From wireline logging of the borehole, a temperature of 14 °C was observed at a depth of ~197 m (Starcher *et al.* 2019). If, as seems likely, the Kiltongue Coal seam was mined beneath the location of this borehole then this legacy of mining may have an influence on the flow of heat in the subsurface and is perhaps a contributing factor as to why the bottom hole temperature, and associated heat flow, is low in comparison to the regional average.

**2. Groundwater flow in mine-workings beneath Glasgow**

Evidence from local geological memoirs is outlined as follows. Robins (1990) reported that Glasgow is the focal point for much of the groundwater discharge from the Central Coalfield with prevailing groundwater flow paths from the east, north-east and south-east. The groundwater flow potential of Carboniferous strata is enhanced by the presence of faults, fractures and abandoned mine workings (Hall *et al.* 1998; cf. Younger *et al.* 2015). Forsyth et al. (1996) state that intersection of flooded workings yielded large supplies of groundwater in the Lanarkshire Basin. Indeed, mine drainage records show that the wettest pits were the Bothwell Colliery [NS 686 588], where a discharge of 230 l/s was constantly removed from a depth of 396 m, and the Kilsyth Colliery [NS  715 779] where 150 l/s were removed from a depth of 206 m. More modest yields were reported from Parkhead [NS 624 647] (25 l/s) and Netherfield [NS 618 647] (25 l/s) and a sustainable borehole yield of 14 l/s near Coatbridge NS [752 642] (Forsyth *et al.* 1996). The requirement to continually pump groundwater from the mines, coupled with the connectivity of workings was a key contributing factor to the decline of the Lanarkshire Coalfield in the early 20th century, notably in the areas from Glasgow to Coatbridge, and Wishaw to Cleland to the east and south-east of the city. As one colliery after another ceased working, the burden of pumping to prevent flooding through the connected workings fell upon those remaining, until it became so great that the plant could not cope with the growth (Scottish Mining 2018).

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**Fig. S1**. Historic map of South Balgray Farm. South Balgray farm existed in the present-day location of Hyndland, western Glasgow. The No. 3 Gartnavel borehole (South Balgray borehole) is located at the site of the South Balgray farm at NS 55780 67810, (BGS Reference NS56NE369), denoted with the red circle. The co-ordinates are in hundred metre intervals within British National Grid 100 km quadrangle NS. *Historic map data: © Crown Copyright and Landmark Information Group Limited (2019). All rights reserved. (1864, 1865).*

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**Fig. S2**. Historic map of Hallside Colliery and Steelworks. The Hallside Steelworks opened in 1872 and was one of the major steel producing centres in Scotland until its closure in 1979. Hallside Colliery opened in 1873 and closed in 1921. The Hallside Borehole is denoted by the red circle. The co-ordinates are in five hundred metre intervals within British National Grid 100 km quadrangle NS. *Historic data: © Crown Copyright and Landmark Information Group Limited (2019). All rights reserved. (1914).*

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**Fig. S3.** Historic map at the locality of the Maryhill borehole, showing proximity of the former Maryhill Ironworks (1877-1950’s). Maryhill Central Station and siding (where borehole is sited) of the former Lanarkshire and Dunbartonshire Railway running in to Maryhill Ironworks. The co-ordinates are in hundred metre intervals within British National Grid 100 km quadrangle NS. *Historic data: © Crown Copyright and Landmark Information Group Limited (2019). All rights reserved. (1914).*