

# The metallurgical enterprises of Richard Boyle, first earl of Cork

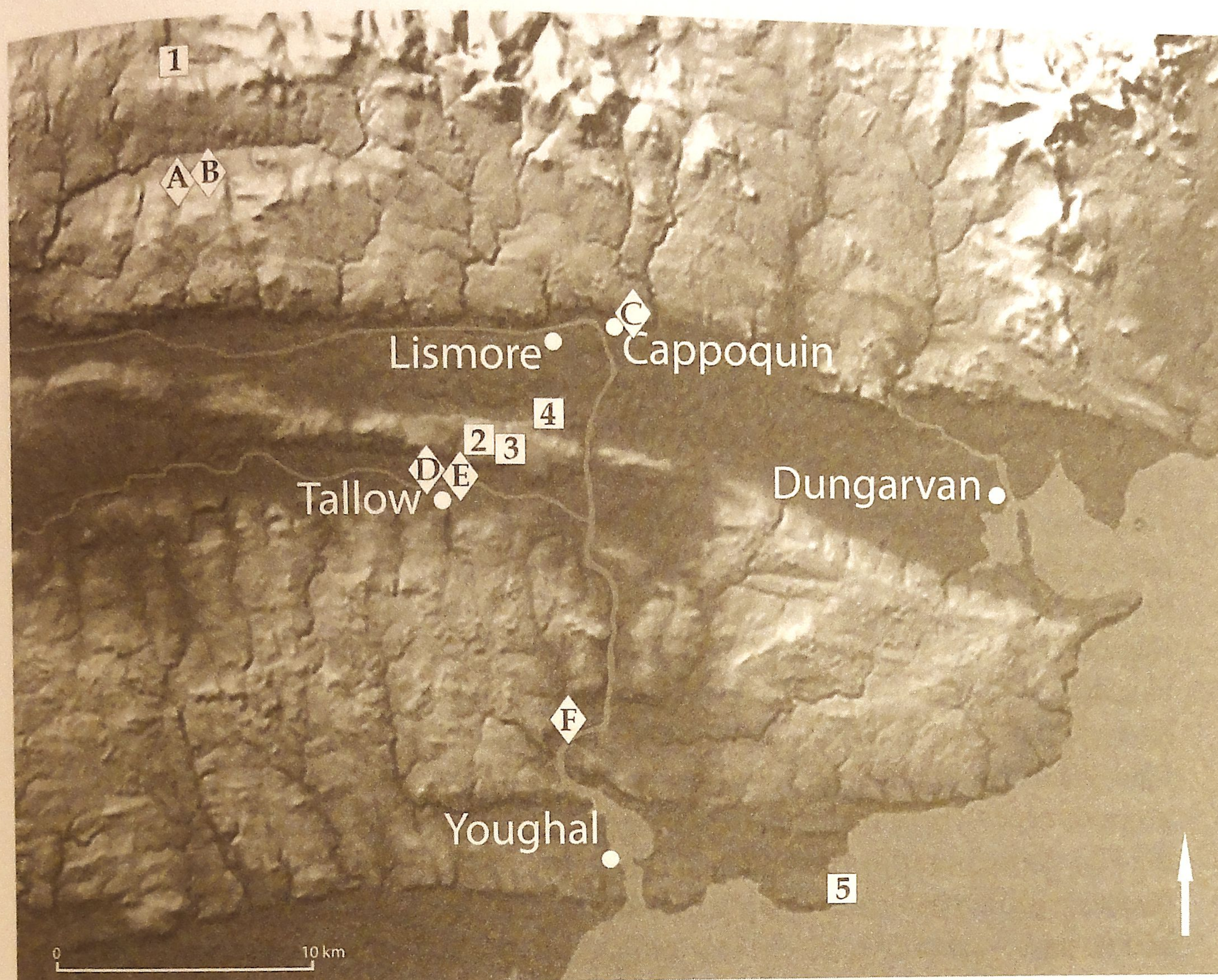
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The Lismore Papers, split between the Chatsworth House and National Library of Ireland archives, constitute one of the most important records on early seventeenth-century metallurgy in Britain and Ireland, and arguably beyond. Until now, however, only Richard Boyle's diary and some other selected Chatsworth documents, supplemented with data from the State Papers, have been used by authors researching Boyle's mining and metallurgy ventures from an Irish perspective.<sup>1</sup> Early overviews, concentrating on the ironworks, were published by Kearney and Power.<sup>2</sup> Some of the information was also used by McCracken in her listing of charcoal-burning ironworks of Ireland and, to a lesser degree, in her treatise on the history of Irish wood use.<sup>3</sup> Many errors concerning the technology used, and the location and the dates of the works, were made in these early works and have found their way into the more general literature. Only Schubert used unpublished information from the Chatsworth archives, mostly to illustrate technological issues of early seventeenth-century ironworking.<sup>4</sup> This contribution, using the available publications together with unpublished material from both archives, presents a chronological framework of Richard Boyle's mines and metal-processing plants. Additionally, the archaeological remains of several of these mines and installations were identified during fieldwork (Fig. 6.1).

Although Richard Boyle is best known for his ironworking ventures, the earliest metal he was involved with was lead. Merchant William Kellett, in 1605, inquired about the amount of lead Boyle had made and his price per stone, while in the following year he stated his interest in 30 to 40 tons of the same.<sup>5</sup> In 1611, Kellett mentioned money disbursed for 'finding out of

<sup>1</sup> See, for example, *LP* 1 and *LP* 2. <sup>2</sup> H.F. Kearney, 'Richard Boyle, ironmaster: a footnote to Irish economic history', *JRSAL*, 82-8:2 (1952-3), pp 156-62; T. Power, 'Richard Boyle's ironworks in County Waterford (Part 1)', *Decies*, 6 (1977), pp 24-31; T. Power, 'Richard Boyle's ironworks in County Waterford (Part 2)', *Decies*, 7 (1978), pp 30-5; T. Power, 'Richard Boyle's ironworks in County Waterford (Part 2 continued)', *Decies*, 9 (1978), p. 18. <sup>3</sup> E. McCracken, 'Charcoal-burning ironworks in seventeenth- and eighteenth-century Ireland', *Ulster Journal of Archaeology*, 20 (1957), pp 123-38; E. McCracken, *The Irish woods since Tudor times: distribution and exploitation* (Newton Abbot, 1971). <sup>4</sup> H.R. Schubert, *History of the British iron and steel industry from c.450BC to AD1775* (London, 1957). <sup>5</sup> NLI, MS 12,813/1, f. 23r; *LP* 2, ii, p. 95





6.1 Richard Boyle's mines and ironworks around Lismore, Co. Waterford. Mines (squares): 1. North of Glenacunna (iron), 2. Ballygarran (iron), 3. Ballygarran (copper), 4. Ballyregan (iron). 5. Ardmore (lead/silver). Ironworks (diamonds): A. & B. Araglin (blast furnaces), C. Cappoquin (double blast furnace), D. Kilmacow (blast furnace and finery), E. Lisfinny (finery), F. Ballynatray (steelworks).

that lead myne' and expressed his hopes in the quality of the ore, and in the following year the merchant prayed that the lead mines would 'fall out well'.<sup>6</sup> These lead-mining activities likely refer to two different locations, neither of which are known.<sup>7</sup>

In early seventeenth-century Europe, iron ores were almost exclusively smelted in blast furnaces. These were large, generally square buildings, several metres high and producing around a ton of iron per day. As opposed to

6 NLI, MSS 13,236/4c and 12,813/1 pp 63-4. 7 Townsend mentions Boyle having lead mines and that he was smelting that metal at Mine Head, Co. Waterford, without referencing a source, while adding that there are also silver mines of considerable value there, worked by Captain Burgh, D. Townsend, *The life and letters of the great earl of Cork* (London, 1904), p. 105. The silver mines clearly refer to Ardmore (see below).



the earlier bloomery furnaces, which produced solid iron blooms, the iron left the blast furnaces in a liquid state. As such it was channelled into moulds that could either result in the production of cast iron objects, such as pots, fire-backs or cannon, or in the making of large blocks of iron, called sows. These sows (later known as pigs) were destined for the finery, where they were resmelted under oxidizing conditions to remove the excess carbon in the iron. The result was forgeable wrought iron, which could subsequently be shaped into different objects by the smith.

In February 1605, a lease was written up between William Chisshull and Thomas Ball for building, within a year, a furnace and a (finery) forge at Kilmacow, Co. Waterford, on land owned by Richard Boyle.<sup>8</sup> By November 1607 the ironworks were built and Cuthbert Bouthe, Jonathan Hampton and Richard Boyle joined the enterprise.<sup>9</sup> Today, the remains of Kilmacow furnace are still visible in the townland of Townparks West as a horseshoe-shaped elevation in the landscape surrounded by copious amounts of mainly blue blast furnace slag. Just to the north is an area with dispersed heavier, iron-rich slag, indicating the location of the finery. Four linear deposits of light coloured material visible from the air,<sup>10</sup> two of which are visible on the ground, represent the clay banks of the leats that fed the wheels for powering the furnace and forge bellows. The eastern-most leat clearly served the furnace, while the others supplied water to the finery, to which others were added later.<sup>11</sup> Initially, Boyle lost money on the Kilmacow venture, but by 1612, he and Thomas Ball became sole owners of the furnace and forge.<sup>12</sup> Up until then, the furnace at Kilmacow was fed with ore and cinders, which were the iron-rich slag from the older, solid-state bloomeries, both imported from the Forest of Dean, close to Bristol.<sup>13</sup> In 1612, however, permission to build blast furnaces inside the Forest was granted to the earl of Pembroke and a year later restrictions on the export of iron ore ('mine') and cinders out of the Forest of Dean were enacted.<sup>14</sup>

As a result of this, Richard Boyle was forced to look elsewhere for ore for his ironworks. By early 1614, iron mines appear to have been already found

<sup>8</sup> NLI, MS 6895, ff. 40-1. In the intervening year William Chisshull received a royal grant to export ore and cinders (see below), to Ireland, PRO SP 14/114, fol. 20. Thomas Ball, also a merchant, was an early investor in the East India Company, as was William Kellett (see above). H. Stevens, *The dawn of the British trade to the East Indies as recorded in the court minutes of the East India Company, 1599-1603* (London, 1886), pp 177, 258, 261; J. Shaw, *Charters relating to the East India Company* (Madras, 1887), p. 18. All other townlands referred to are located in the same county. <sup>9</sup> NLI, MSS 43,096a and b; Jonathan Hampton is described as a mariner from Bristol (ibid.), Cuthbert Bouthe was Thomas Ball's father-in-law. <sup>10</sup> Ordnance Survey Ireland Mapviewer (<http://maps.osi.ie/publicviewer>, accessed 15 Jan. 2014), Ortho 2005. <sup>11</sup> By 1618, there were already four fineries at Kilmacow, NLI, MS 43,297/2a. <sup>12</sup> NLI, MS 43,297/1b and LP 1, i, pp 10-11. <sup>13</sup> Ibid., pp 120-3; NLI, MS 12,813/1, ff 39-40, 41, 42, MSS 43,297/1a and d, MS 43,299/1a. <sup>14</sup> Schubert, *History*, pp 185-6; H.G. Nicholls, *The Forest of Dean; an historical and descriptive account* (London, 1858), p. 25.



or, at least, strongly expected.<sup>15</sup> In late January of the following year Ellen Stanley gave permission to search for iron ore on her lands at Ballyregan,<sup>16</sup> which is the earliest reference found to what would become Richard Boyle's most important mine. As the main ore body was located at the bottom of a valley, the mine could only function with pumps. Two of these were eventually employed at Ballyregan, which were themselves water-powered (Plate 9a).<sup>17</sup> This mine, its large spoilheap, the leat for the mills activating the wheels and the dam for retaining the water are preserved in the townland of Deerparkhill. Ballyregan mine was worked till at least 1629.<sup>18</sup> Another iron mine, at Ballygarran, now in the townland of Knockroe, was opened before 1618 and was also still active in 1629.<sup>19</sup> This mine was similarly equipped with water-powered pumps, the leat of which is still visible in the field.<sup>20</sup> Further iron ore, known as mountain ore, was mined in the Drum Hills, near Aglish, east of the Blackwater river.<sup>21</sup> Here a water-powered pump, albeit a smaller one, was also used, interestingly mentioned as for the 'oulde worcke'.<sup>22</sup> Ore was also occasionally obtained from other places, such as Kilmacow before 1618 and 'the baye beyond Ardmore' in 1619, while trials for iron ore were carried out at Lismore and Ballygalane in the same year.<sup>23</sup>

Shortly after Ballyregan mine was started up, in 1615, a lease was made with Thomas Ball to take over the newly found mines and to build a double furnace and forges either at Cappoquin or at Ballyrafter/Ballyin, two townlands across the river from Lismore Castle.<sup>24</sup> In the end the choice fell on Cappoquin, but instead of building fineries there, the forge at Kilmacow was worked 'dubble handed night & day'.<sup>25</sup> The double furnace was located in a field close to the centre of Cappoquin known up until recently as 'the Cinders'.<sup>26</sup> A visit to the site, just after a narrow trench was cut through the field for gasworks, revealed large amounts of blast furnace slag. A slight elevation nearby might indicate the location of the works.

<sup>15</sup> NLI, MS 12,813/1, p. 81, referring to an unconsulted document at Chatsworth, mentions the profits of the iron mines in Counties Cork and Waterford to be halved between Richard Boyle and Thomas Ball. <sup>16</sup> Ibid., p. 101. <sup>17</sup> See, for example, the inventory of this mine in Schubert, *History*, p. 407. <sup>18</sup> *LP* 1, ii, p. 197. <sup>19</sup> Ibid.; NLI, MS 43,297/2a. <sup>20</sup> NLI, MS 43,297/2a. <sup>21</sup> CHA, Cork MSS, miscellaneous, box 2, account book for mines, 1619, f. 18v. One of the locations, Ballicarrane, likely refers to Ballycurrane, Ballycurrane South or Ballycurrane North, three adjoining townlands, while the other, Tobberneagenaghy, could not be located. The ore from here was brought to Bewley, on an eastern tributary of the Blackwater, to be shipped to Cappoquin furnaces, *ibid.*, f. 8v. <sup>22</sup> Ibid., fol 18v; NLI, MS 43,297/2a. <sup>23</sup> CHA, Cork MSS, miscellaneous, box 2, account book for mines, 1619, ff 8r and 15r. <sup>24</sup> Two slightly different leases were drawn up for this transaction, NLI, MS 43,149/b (16 June), and NLI, MS 43,149/x (20 Nov.). The latter document is present in bundle 43,149, but was not included in the relevant calendar by S. Ball, *Collection list no. 129. Lismore Castle Papers* (Dublin, 2007), pp 99–100. <sup>25</sup> NLI, MS 43,280a. <sup>26</sup> G. Redmond, 'History, antiquities, archaeological remains, and legends connected with the western end of the County Waterford', *JRSAI*, 7:65 (1886), 394–405, p. 403; M. O'Sullivan and K.M. McCarthy, *Cappoquin: a walk through history* (Cappoquin, 1999), p. 291.



On 24 April 1616, Boyle received 56 double bars of Spanish iron and 28 single bars from John oge Fitzgerald and his wife Honora as part of his iron-works in Rinkynefeck, identifiable as Ring or *Rinn an Chinifeicigh*, on the Knockadoon peninsula south-west of Youghal.<sup>27</sup> Spanish iron usually refers to a type of iron from the Basque region, but in this case it possibly indicated a certain shape of the bars. These were not the only metalworking activities that the neighbouring Fitzgeralds were engaged in. Later entries, from 1620 and 1621, mention mines at Ballymullallagh on land redeemed from Sir John Curious Fitzgerald.<sup>28</sup> It is unclear if the ore mined here was for producing iron. A curious event occurs in 1625, when Richard Boyle sets some of his men to work in the iron mines at Rathnemeenagh only to be expelled about two months later by John Fitzgerald and others.<sup>29</sup> Sergeants of Fitzgerald came back two months later to evict the workers again, who had returned to the mine.<sup>30</sup> A cursory visit to both Ring and Ballymullallagh did not reveal any remains of either ironworks or mines. Also of interest is Drumslog, where both Steward in 1800, and the 1840 Ordnance Survey map, record iron mines at this location.<sup>31</sup> Many sources attribute these mines to Sir Walter Raleigh, with Power further claiming that they subsequently came into Boyle's possession,<sup>32</sup> but no references to original sources for this claim have been found. The most obvious remains at Drumslog, a large open-cast mine with large spoilheaps, does not appear on the earliest Ordnance Survey map, which does show shafts, located further away from the road and now obscured by vegetation. Later iron-mining activity at Drumslog, in the 1850s and 1860s, which was seemingly limited to trials for ore,<sup>33</sup> is clearly not responsible for the large pit still visible.

Sir Walter Raleigh was on his way back from Venezuela, where he had been searching for El Dorado, when he visited Richard Boyle in Ireland in 1617 and agreed, in August of that year, on a partnership to exploit the newly found copper mine at Ballygarran.<sup>34</sup> Shortly after, 'yield' from Ballyregan mines was sent to Richard Fowler, a refiner (assayer) and brother of Raleigh's

<sup>27</sup> *LP* 1, i, p. 109. <sup>28</sup> *Ibid.*, i, p. 146; ii, p. 8. <sup>29</sup> *Ibid.*, p. 151. <sup>30</sup> *Ibid.*, pp 156-7. <sup>31</sup> D. Stewart, 'The report of Donald Stewart, itinerant mineralogist to the Dublin Society', *Transactions of the Dublin Society*, 1:2 (1800), pp 1-142, at p. 136, describes the location as 'In the side of the mountain, near the road from Youghal to Dungarvan, about half-way, is a large body of rich dark-coloured iron ore, where great pits were made in raising it, by the Danes, as I was informed'. <sup>32</sup> See, for example, R. Griffith, 'Catalogue of the several localities in Ireland where mines or metalliferous indications have hitherto been discovered, arranged in counties according to their respective post towns', *The Monthly Journal of Progress*, 1:10-11 (1854), pp 287-93, 324-30, at p. 328 and G.A.J. Cole, *Memoir and map of localities of minerals of economic importance and metalliferous mines in Ireland* (Dublin, 1922), p. 87. According to G.H. Kinahan, 'On Irish metal mining', *The Scientific Proceedings of the Dublin Society*, 5 (1887), pp 200-317, at p. 301, Drumslog, Ardmore and Mine Head (see above) were all iron mines, the latter two especially suited for making steel! See also T. Power, 'Richard Boyle's ironworks (Part 2)', p. 35: this article contains many errors. <sup>33</sup> D. Cowman, 'Landlords and their minerals c.1850: two Waterford case studies', *Decies*, 47 (1993), pp 16-21, at pp 18-21. <sup>34</sup> *LP* 1, i, pp 162-3.





6.2 Standing remains of furnace of *c.*1623 at Araglin, Co. Cork  
(photo: Colin Rynne).

refiner, living in Delft in the Netherlands.<sup>35</sup> The next day, letters were sent to Peter Coortup of London, together with ore 'to make tryall of the goodness thereof' and to Sir Allen Apsley about a lease of the Royal (in this case, silver) Mines of Munster.<sup>36</sup> Five pounds of copper ore was again sent to Richard Fowler, this time described as from Rotterdam, in June of the next year.<sup>37</sup> Richard Boyle also showed interest, in October 1617, in an unspecified lead mine in Co. Kerry leased by the Company of Minerals and Battery Works.<sup>38</sup> No information on actual production of non-ferrous metals from these mines was found, but a smaller open-cast mine located several hundred metres east of Ballygarran iron mine might represent extraction of non-ferrous metals.<sup>39</sup>

<sup>35</sup> *Ibid.*, p. 163. <sup>36</sup> *Ibid.* <sup>37</sup> *Ibid.*, p. 193. <sup>38</sup> NLI, MS 13,236/12g, f. iv. <sup>39</sup> A mine



In early 1619, Thomas Ball surrendered his part in the ironworks, after which Richard Boyle became sole owner.<sup>40</sup> This was followed by the construction of a double finery at Lisfinny in 1621, directly across the river Bride from Kilmacow and in 1624 a nailhouse was built at Tallowbridge, comprising a slitting mill and no less than eight forges and hearths.<sup>41</sup> The forges and hearths, in this case, would have been smithing installations and the slitting mill would have included both a rolling mill, for making plate iron, and an installation to slice the plates into rods, which were then cut and hammered into nails.<sup>42</sup>

The continued search for iron ores paid off in 1624, when new occurrences were found around the valley of Araglin.<sup>43</sup> These were promising enough to encourage Richard Boyle to build two new blast furnaces in that valley in the middle of the next year.<sup>44</sup> One of the furnaces at Araglin, in the townland of Knockbaun, is still preserved, although only the lower part of the building dates to the seventeenth century (pers. comm. Dr Colin Rynne). This furnace has its blowing arch preserved, while the casting arch has recently collapsed (Fig. 6.2 and Plate 9b). The location of the other furnace, just west of Kingston Bridge, on the south side of Araglin river, in the townland of Ballinaleucra, is marked by the occurrence of amounts of blue blast furnace slag. Trial of the ore near Araglin suggested it was suited for casting ordnance and in March 1626 cannons were made at Cappoquin.<sup>45</sup> The Araglin mines which are described as situated north of Araglin river near Glanconogh/Glanconnagh,<sup>46</sup> or Glenacunna valley, cannot yet be located.

In that same year, 1626, two of the most important employees in Richard Boyle's ironworks, Richard Blacknall and Henry Wright, had devised a plan for producing both bar iron and cast ordnance in Ireland, which would have undercut Richard Boyle's ventures.<sup>47</sup> Blacknall and Wright claimed to have ownership of the Tallowbridge nailhouse, while the mines at Araglin and various woods, which were not on Boyle's lands, were to be taken into Royal possession. A furnace was to be set up near Macroom, Co. Cork, where further iron mines had been found.<sup>48</sup> Later, the partners, now joined by Luke Brady of Tuamgraney in Co. Clare, who had further iron mines, asked for a monopoly on ordnance and bar iron production in Ireland, which was granted to them in November 1628.<sup>49</sup> The Araglin mines, which were located on the lands owned by Sir William Fenton, were indeed secured by the crown in 1629, but the earl of Cork had

at Ballygarran was earlier mentioned as wrought for lead, NLI, MS 43,297/2a. <sup>40</sup> *LP* 1, i, p. 214. <sup>41</sup> *Ibid.*, ii, pp 4, 6, 120-1. <sup>42</sup> Schubert, *History*, p. 307. <sup>43</sup> PRO SP 63/268, f. 25. <sup>44</sup> *LP* 1, ii, pp 160-2. <sup>45</sup> *Ibid.*, p. 179; PRO SP 63/268, f. 25. The reference, in December 1623, to Dutchmen working at Kilmacow furnace could indicate that ordnance production was produced or planned earlier, NLI, MS 13,237/6c. <sup>46</sup> PRO SP 63/246, f. 65; *CPRI, James I*, p. 509. <sup>47</sup> PRO SP 63/268, f. 25. <sup>48</sup> The document refers to mines and potential furnaces in Co. Cork, located 30 miles west of Tallow. Later references place this near Macroom in that county. See, for example, *APC*, July 1628-Apr. 1629, pp 72-3. <sup>49</sup> *Cal. SP, Ire., 1625-32*, pp 399-400.



earlier obtained the rights to the Araglin mines belonging to Sir Richard Everard.<sup>50</sup> In the end, the partners were unsuccessful in their scheme, apart from being confirmed in their possession of Tallowbridge nail-house.<sup>51</sup>

Sir Richard Boyle, on the other hand, expanded his operations. In March 1629, he was contacted by Thomas Ledsham or Letsome, who proposed to make steel for him and a week later Boyle wrote to Sir Charles Coote with a proposition to jointly construct furnaces and forges in Co. Leitrim.<sup>52</sup> His involvement with the latter scheme was short-lived, but profitable; Boyle invested £1,500 in 1629 and sold his shares in the venture for £3,000 two years later.<sup>53</sup> The steel-making operation was located at Ballynatray, Co. Waterford, and was centred around a cementation furnace. The cementation furnace was a relatively new method of steel production whereby pieces of wrought iron were encased together with organic material that were heated with coal.<sup>54</sup> Normally the organic material was charcoal, but at Ballynatray, seemingly turf was used.<sup>55</sup> Small amounts of steel were made in 1631, but most ended up as 'refuge steel', 7 tons of which were sold at £20 per ton in 1638, testifying to its poor quality.<sup>56</sup> Lumps of slag were found just below a derelict flour mill on the northern side of the Ballynatray estate, likely pointing to the location of the steelworks. As the lumps were large and contained charcoal, both incompatible with cementation steel-making slag, they were probably the result of activities carried out after the conversion of the plant (see below).

In 1632, we have the earliest reference to the mining of silver at Ardmore, Co. Waterford, when the mines are let by Richard Boyle to Captain Burgh for seven years.<sup>57</sup> This undertaking seems to be related to the discovery of the mines at what today is Silvermines in Co. Tipperary.<sup>58</sup> The Ardmore mines are recorded up to 1636, but are then described as lead mines.<sup>59</sup> The main adit of the mine is still visible at the base of the cliffs under St Declan's Church and were earlier described by Cowman.<sup>60</sup> Previously, access was seemingly also possible from above, as mineralogist Steward describes descending a shaft at Ardmore mines around the year 1800.<sup>61</sup>

In the same period, Richard Boyle's ironworks underwent important changes. He still acquired new ironworks, belonging to Luke Brady (see

<sup>50</sup> CPRI, p. 509; LP 1, ii, p. 252. <sup>51</sup> A temporary ruling to that effect was passed in 1627 and subsequently confirmed at least twice, *Cal. SP, Ire.*, 1625-32, p. 310 and *APC*, July 1628-Apr. 1629, pp 108-9; Boyle does not mention the nail-house after this. <sup>52</sup> LP 1, ii, pp 505-6. <sup>53</sup> *Ibid.*, iii, pp 79-80. <sup>54</sup> In Schubert, *History*, pp 323-4. <sup>55</sup> NLI, MS 6897, 1 July 1631. <sup>56</sup> LP 1, iii, p. 83; v, p. 52. <sup>57</sup> *Ibid.*, iii, p. 132. <sup>58</sup> Captain Burgh is recorded as working 'the Royal Mines of Munster' from around 1629, which appear to be those at Silvermines, Sheffield Archive, Wentworth Woodhouse Muniments. *Strafford Papers* 24-25, ff 378-80. When, in early 1634, Captain Whitmore, the new patent holder for Silvermines, and Mr Scott sailed to England with bars of silver made in Ireland, they leave from the earl of Cork's estates, W. Knowler, *The earl of Strafforde's letters and dispatches*, vol. I (London, 1789), pp 218-21; LP 1, iv, p. 12. <sup>59</sup> *Ibid.*, pp 21, 51, 198. <sup>60</sup> D. Cowman, 'Dating the mines at Ardmore', *Ardmore Journal*, 10 (1993), pp 22-30. <sup>61</sup> D. Stewart, 'The report of Donald Stewart', p. 135.



above) at Scarriff, Co. Clare in 1634, but no information was found on activity there in the following years, suggesting the purchase might have been to stifle potential competition.<sup>62</sup> A new slitting mill was constructed at Lisfinny in 1633 by Thomas Ledsham who had previously introduced the steelworks, but the following year the mill was specified as processing 'unmarchantable iron'.<sup>63</sup> In 1636, the steelworks at Ballinatray were converted into an installation for re-smelting scrap iron and iron-rich finery slag into wrought iron, which likely gave rise to the lumps of slag found there (see above).<sup>64</sup> A year later, Lisfinny forge was re-designed for a similar purpose and Kilmacow forge was converted into a tucking mill.<sup>65</sup> By the end of 1641, a total of 53 tons of bar iron was produced from waste materials at Lisfinny.<sup>66</sup> The documentation consulted mentions no reasons for this concentration on recuperating metal from waste, but a depletion of the available iron ore sources seems a strong possibility.

This was, however, not the end of Sir Richard Boyle's involvement in metalworking. In 1641, two iron cannons were cast for the defence of Lismore Castle and the following year their testing was overseen by the then 15-year-old future scientist Robert Boyle.<sup>67</sup> In May 1643, just over four months before the last entry in his diary, Sir Richard Boyle wrote out a new contract for the running of one of the ironworks, presumably a furnace, but its location is unclear, which mentions that 8000 tons of timber would suffice to keep it going for another 10 years.<sup>68</sup>

The exploitation of the mineral resources was clearly an important part of the Richard Boyle's plantation scheme. It would seem that some kind of metallurgical enterprise was being carried out at all times from him taking over the estate from Sir Walter Raleigh until Boyle's death in 1643. In general, the methods and installations used were those commonly available in Britain, while occasionally innovative technologies were introduced, either out of necessity (the water-powered mine pumps at Ballyregan) or purely as an investment (the steelworks). The extraction of the metal ores and their processing by Richard Boyle have left copious traces both in the written record and in the landscape. Combined, these represent a unique record of seventeenth-century industrial activity in Ireland, which undoubtedly merits further research and recognition.

<sup>62</sup> *LP* 1, iv, pp 35-6; v, p. 40. <sup>63</sup> NLI, MS 12,813, pp 437-8; weekly payments for the construction of Lisfinny slitting mill are recorded from 16 Nov. until 21 Dec. 1633, NLI, MS 6898; 'unmarchantable iron', *ibid.*, 22 Feb. 1634. <sup>64</sup> *LP* 1, iv, p. 203. <sup>65</sup> NLI, MS 43,096d; NLI, MS 6239, ff 74-9. <sup>66</sup> NLI, MS 6898, 16 Oct. 1641. <sup>67</sup> *Ibid.*, 4 Dec. 1641; *LP* 1, v, p. 201; Anon., 'Home made cannon', *Irish Sword: Journal of the Military History Society of Ireland*, 7 (1965), p. 135. <sup>68</sup> *LP* 1, v, p. 226.