The Social and Technological Context of Iron Production in Iron Age and Early Medieval Ireland c. 600 BC – AD 900

Volume 1 of 2

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SUMMARY

This thesis investigates the technology of iron production in Iron Age and early medieval Ireland and, through two case studies, situates iron production in its social context. Archaeological evidence from 202 sites, many recently excavated and unpublished is analysed, allowing the characterisation of the archaeology of Irish smelting and smithing sites, including features such as furnaces and smithing hearths as well as associated finds and structures.

An Iron Age case study focuses on an iron producing region in the Irish midlands. This area has produced a significant number of dispersed, isolated and small-scale smelting sites from the period, as well as a very small number of smithing sites associated with ritually significant hilltop sites. It is argued that smith/smelters in the Iron Age of the region played a significant role in what was probably a mobile, pastoral society. They had a dual role as both craft-workers and ritual specialists, smelting iron in isolation before creating desirable objects at places of communal ritual and ceremony.

A second case study focuses on the idea of the ironworker as a specialist in early medieval society. It is argued that the role of ironworkers changed significantly at the beginning of the period with the arrival of Christianity and the appropriation of iron technology by the Church, which organised the first large-scale specialist smithing in the country. As the period progressed smithing became a more common activity, carried out by a spectrum of workers including high-status secular smiths working on a very large-scale.
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1. AIMS, METHODOLOGY AND PREVIOUS APPROACHES

Iron is a substance familiar to archaeologists as both a ubiquitous modern metal and as the defining material of one of the ‘ages’ that dominate the way we partition the past. It has been a crucial material in Europe for more than three millennia, critically important to many aspects of life for early communities preoccupied with agriculture (tools and equipment), bent on warfare (weaponry), and with sophisticated systems of patronage, production centres and trade networks. Despite its importance, early attitudes to iron were not always positive: it was a mysterious and capricious metal, difficult to work, but invaluable as both weapon and tool, taking and sustaining life (Wertime 1980, 4-7). In more recent times iron has been crucial to archaeologists and antiquarians as a marker of relative chronology within Thomsen’s three-age system (cf. Thomsen 1836; Trigger 1989, 73-79) but its prominence in our chronological understanding of the past has arguably failed to attract research commensurate with its significance as a technology and a material, particularly in Ireland (with notable exceptions e.g. O’Kelly 1952; 1961; 1963; Scott 1990; Mytum 1992, 229-235; Carlin et al. 2008b; Wallace and Anguilano 2010b). What follows here is a small attempt to redress this balance, focusing on evidence for the production of iron in Ireland from the introduction of iron technology in the first millennium BC to the arrival of Scandinavian iron technology in the ninth century AD (Figs. 1.1-1.4 and Table 1.1).

This study takes advantage of the explosion in the number and quality of archaeological excavations in Ireland in the last two decades. It follows on from scholars such as M.J. O’Kelly and Brian Scott, whose work – particularly Scott’s (1990) comprehensive synthesis Early Irish Ironworking – has been the lens through which archaeologists have viewed the archaeology of iron production in Ireland for two decades. It also relies heavily on the, generally unpublished, analytical studies of the many archaeometallurgical specialists working on recent Irish slag assemblages and ironworking features. Awareness and understanding of iron technology within Irish archaeology has suffered, particularly in the last two decades, from a lack of new
research and publications (though there have been notable exceptions to this e.g. Crew and Rehren 2002; Carlin et al. 2008b), despite the massive increase in excavations seen during the same period. Equally, there has been very little attention paid to the social context of iron production in the two periods covered here: the Iron Age and the early medieval period (although see Mytum 1992; Raftery 1994; Becker et al. 2008; O’Sullivan and Harney 2008a; 2008b; Becker 2009; O’Sullivan et al. 2010a for important exceptions). The limited amount of research has largely been a result of a historic deficit in data but this study takes advantage of a large corpus of recently excavated relevant sites to provide a new understanding of the social context of iron technology in the Irish Iron Age and early medieval periods.

Aims and Objectives

While there has been a huge increase in the quantity of excavations in Ireland in the past two decades, perhaps more important has been the increase in the quality and scale of post-excavation work made possible by the availability of considerable funding. This has corrected, to a significant extent, the lack of good data faced by Scott when compiling his synthesis of early Irish ironworking evidence (cf. Scott 1990, 216). A primary aim of this project is to review this new evidence in light of current understandings of iron technology, and to characterise the archaeological features and finds associated with iron smelting and smithing in Ireland. Much of this new information exists in the form of unpublished excavation and specialist reports, thus a secondary goal was to collate, re-interpret and make accessible this material through the creation of a project database entitled The Irish Iron Database. This re-evaluation of the archaeological material was crucial to the ultimate goal of the study, which is to contribute to an understanding of the social context of iron technology in ancient Ireland: the role iron technology, particularly iron production, played in the social lives of Iron Age and early medieval people through the creation and maintenance of identity as well as social, political and economic relations. This is a very broad objective and so a small number of research questions were formulated to serve as focal points in the analysis of the data:

1. What technologies were used in the smelting and smithing of iron, what signature have they left in the archaeological record and how have they changed through time?
2. How was iron production organised in the Iron Age and early medieval periods and what implications does this have for the wider organisation of society?
3. What was the scale of iron production in different times and places and what implications does this have in terms of the control of production, identity, status and ritual/practical knowledge?
4. Who were the producers of iron in the Iron Age and early medieval periods, what role did they play in society and to what extent were they specialists?

The first research question focuses on a basic understanding of the technology of ironworking used in Ireland. Understandings of early iron technology, particularly in relation to smelting, have changed significantly in the past two decades (cf. Crew 1991; Crew 1995a; Stanley 1995; Crew 1996; Pleiner 2000; Serneels and Perret 2003; Pleiner 2006; Crew and Charlton 2007; Paynter 2007a) and while this has been recognised to some extent in Ireland (e.g. Crew and Rehren 2002; Carlin et al. 2008b; Wallace and Anguilano 2010b) there is a pressing need for a re-evaluation of the Irish evidence. As part of this, the physical remains that ironworking left in the archaeological record – i.e. the features and finds associated with smelting and smithing – require re-interpretation and characterisation in light of new excavations. This systematic and comprehensive re-interpretation of the data provides a basis from which to address the other questions which are focused on the social context of iron technology.

The organisation of iron production: mining, smelting, smithing etc. changed through time both in terms of its location in the landscape as well as the types of sites with which these activities were associated. At all times it was based on social ideas about how, where and by whom such activities should be carried out (Thornton 2009, 26-27). Similarly, the scale of production varied across time and space and was a product of numerous technological choices based on technical, economic and social factors. These choices were inscribed in the landscape through material culture and it is an analysis of the material remains of these decisions – the smelting furnaces, smithing hearths, slag, tools and the sites where they were used – at a variety of scales: national, regional and local, which allows their reconstruction.

The identification of ironworkers through archaeological evidence is difficult, but it is possible to gain some sense of their social lives i.e. what other roles they played in society; to what extent they used their work with iron technology to define and maintain their identities and status; and what influence their involvement with iron had on their wider social relations. For instance, historical evidence from early medieval Ireland strongly suggests the existence of specialist iron producers in that period whose status, wealth and personal identity were defined by their craft (Kelly 1988; Scott 1990, 171-212). However, it is not clear to what extent this was the case in the Iron Age, or even whether archaeological evidence supports this view throughout the early medieval period. These issues of identity and specialisation will be explored here through contextual analysis of ironworking sites: using the activities and site types associated with the work of ironworkers to explore their place in society.
Academic considerations of iron technology in Europe have their roots in Renaissance treatises on metallurgy such as Biringuccio’s *Pyrotechnia* published in 1540 and Agricola’s *De Re Metallica* published in 1556 (Hoover and Hoover 1912; Smith and Gnudi 1942). These both discuss the classical texts dealing with metals and minerals, primarily Pliny’s *Natural History* (Rackham 1952) published in the first century AD, and were essentially considerations of technical aspects of metal production: techniques of mining, smelting, and refining (Piaskowski 1988; Craddock 1995, 2). The beginnings of metallurgical analysis of archaeological specimens can be traced back to the nineteenth century AD (Scott 1974b, 88). The first modern account of the history of iron in English was contained in Percy’s (1864) *Metallurgy*. Percy used ethnographic accounts of contemporary direct iron-smelting from around the British Empire to reconstruct ‘primitive’ iron-smelting technology. Working in parallel, Beck (1884) presented a broad synthesis of historical, ethnological and, occasionally, archaeological knowledge concerning the history of iron production (Pleiner 2000, 1). In the first half of the twentieth century Beck’s work was succeeded by Johannsen (1924; 1925; 1953), while Forbes (1950) contributed a broad synthesis of European metallurgy, including iron. Metallurgical analysis of a few ancient artefacts was undertaken (Bell 1912; Hanemann 1913; 1922; Gérard 1926; Thyssen 1927; Newton-Friend 1928; Hanemann 1930), mainly in an attempt to compare technological advancement in different regions or periods. Later, Rieth (1942) and Salin and France-Lanord (1943) would improve the methodology for studying ancient metals while integrating it better with the archaeological context of the artefacts studied (Scott 1974b, 88-89). A number of papers (e.g. Richardson 1934; Przeworski 1939; Rickard 1939; Witter 1942) published prior to the second half of the 20th century capture the fairly basic understanding of iron’s history that then existed, based primarily on historical sources. Some reviews of ironworking remains in regional localities (e.g. Straker 1931) were published, and they mark the beginnings of an archaeological approach to the study of iron, culminating in the first critical review by Weiershausen (1939) of early ironworking remains (Pleiner 2000, 1). At the same time the realisation that a large variety of traditional ironworking processes were still being practised or were preserved in living memory (e.g. Crawhall 1933; Cline 1937), even in Europe (e.g. Busch 1972), opened new possibilities for using ethnographic parallels to explain and reconstruct early European iron technology.

After World War II the study of ancient metals or ‘archaeometallurgy’ began to develop as a separate and coherent discipline, drawing on archaeology, metallurgy and the physical sciences (Craddock 1995, 5-6). The 1950s saw a number of major works (Coghlan 1956;
Schubert 1957), but the publication of Tylecote’s *Metallurgy in Archaeology* (1962a) can be seen as a seminal moment in the development of the discipline (Cleere 1989, 194; Craddock 1995, 5-6; Bayley 1998, 161) and his chemical and mineralogical approach would influence and be developed further in relation to ironworking by a large number of researchers (e.g. Morton and Wingrove 1969; Hedges and Salter 1979; Bachman 1982; Salter 1982; Kresten and Serning 1983; Tylecote and Gilmour 1986; McDonnell 1991; Serneels and Crew 1997; Serneels and Perret 2003; Joosten 2004; Crew and Charlton 2007). The investigation of iron technology in this period was spurred on by the involvement of modern ironworkers, who brought specialised technical and scientific knowledge to the study of ancient artefacts and industries (Pleiner 2000, 1). Realisation of the lack of technical understanding of early iron processes led to experimental reconstructions based on excavated evidence. While there had been sporadic early trials (e.g. von Wurmbrandt 1877; O’Kelly 1952; Sadzot 1956; O’Kelly 1961), the late 1950s and early 1960s saw systematic work in a number of important European ironworking areas (e.g. Gilles 1958; Wynne and Tylecote 1958; Radwan and Pleiner 1963; Thomsen 1964; Straube *et al.* 1965; Hagfeldt 1966; Pleiner 1969; Cleere 1971a; Tylecote *et al.* 1971). At the same time, the systematic analysis of medieval iron artefacts from Russia by Kolčin (e.g. 1953; 1958; 1959) represented a methodological breakthrough in terms of the generation of statistically reliable and focused chronological and geographical analysis of iron production (Scott 1974b, 89). The 1960s also saw the establishment of a number of important organisations and journals for the study of iron and early metals including the Historical Metallurgy Society and Wealden Iron Group in England, the *Geschichtsausschuß des Vereines der Deutschen Eisenhüttenleute* in Germany, the *Revue d’Histoire de la Sidérurgie* in France and, internationally, the *Comité pour la Sidérurgie Ancienne de l’UISPP*. These organisations facilitated a cohort of interested and connected scholars involved in the study of iron and led to a boom in conferences and other research activities (see Pleiner 2000, 2-6).

The early investigations of metals and the development of archaeometallurgy were rooted in a cultural-historical paradigm that explained technological development through diffusion, migration and evolution. They were heavily influenced by the work of Childe (e.g. 1940; 1942; 1944) who conceptualised metals as important markers of technological ‘revolutions’ punctuating the evolution of societies (Budd and Taylor 1995, 135-136; Thornton 2009, 27-28). This traditional theoretical model, developed by Childe without the benefit of modern scientific analysis, was the background to much early research on ironworking which neglected engagement with social theory in favour of methodological development, technical understanding and data gathering, with a concentration on the development of an historical chronology of iron technology (e.g. Coghlan 1956; Tylecote 1962a; Tylecote 1976; Wertime
and Muhly 1980). These preoccupations with technical aspects of iron technology have persisted within iron-studies, despite intermittent criticism (e.g. Salter 1989, 251; Ehrenreich 1991a; Cleere 1995, 213; Bayley 1998). By the 1970s and 1980s review articles were beginning to appear, taking stock of the state of knowledge in the area and identifying remaining difficulties in explaining technical aspects of iron technology (e.g. Cleere 1972a; Scott 1974b; Pleiner 1980; Tylecote 1980; Tylecote and Merkel 1985; Cleere 1989). There was a continuing drive to explain and understand fully the technological processes sketched out in the preceding decades, particularly in terms of the waste materials associated with ironworking processes (e.g. Eketorp 1972; Sperl 1980; Bachman 1982; McDonnell 1983; Tylecote and Clough 1983; Bjorkenstam 1985; Kresten 1987; McDonnell 1988a; Piaskowski 1989; McDonnell 1991), and experimental work aimed at understanding technical processes and material remains continued (e.g. Bielenin 1973; Adams 1979; Clough 1987; Tholander 1987; Crew 1988; Crew 1991). Metallurgical examination of artefacts also continued with a developing understanding and identification of blacksmithing techniques and with a continuation of regional studies inspired by Kolčin’s work (e.g. Pleiner 1973; McDonnell 1987a; Ottaway 1987; McDonnell 1989; Piaskowski 1991). The development of the chemical and mineralogical techniques pioneered by Tylecote (1962a; 1976) led to work on provenancing (Hedges and Salter 1982) as well as elements of the technological process such as refractory ceramics (Tite et al. 1985; Freestone and Tite 1986; Freestone 1989).

Goodway (1991) identified a paradigm shift in the 1980s within the broader discipline of archaeometallurgy, from a preoccupation with objects towards an emphasis on materials and context, away from art-historical approaches and technical histories towards archaeology and material culture. Thornton (2009) argued that what Goodway identified was not a paradigm shift but rather the maturation of the discipline and a new focus on augmenting archaeological understandings of how metallurgical technologies were integrated into society, though with the traditional interest in technical processes continuing (e.g. Tylecote 1986; 1992; Craddock 1995; Pleiner 2000; Buchwald 2005; Pleiner 2006). Arguably, the shift towards contextual studies identified by Goodway (1991) has only become firmly entrenched in the 21st century (Thornton 2009, 29). A similar development can be seen specifically within the field of iron research, though interest in the detritus associated with iron production: ore, slag, charcoal, refractory linings, tuyeres etc. developed earlier, manifested in early experimental work (discussed above) and chemical and mineralogical analyses of archaeologically excavated materials (e.g. Piaskowski 1965; Morton and Wingrove 1969; cf. Pleiner 2000, 1-2). The 1980s saw the development of a significant interest in the socio-economic context of ironworking led by scholars such as Cleere (e.g. 1981; 1983; 1987; 1989; 1995), Ehrenreich (e.g. 1985; 1987;
1991a; 1991b) and others (e.g. Hyenstrand 1979; Scott 1981c; Salter 1982; Salter and Ehrenreich 1984; Cleere and Crossley 1985a; Geselowitz 1988; Scott 1990; Geselowitz 1993). These were, for the most part, regional studies influenced by processual theory and focused on answering economic questions about ‘iron industries’ as well as developing systemic models to explain how iron technology was integrated into society.

In the last two decades interest in the socio-economic context of ironworking has continued alongside more traditional, technical studies, though a number of significant new approaches have emerged. An important development in the last two decades has been the increased interest in the potential symbolic and ideological significance of iron technology. In particular, research on ironworking in Africa (e.g. Childs 1991b; Childs 1991a; Herbert 1993; Reid and MacLean 1995; Schmidt 1996; 1997; Schmidt and Mapunda 1997; Childs 1999; de Barros 2000; Vogel 2000; Barndon 2004), influenced by ethnographic and ethnoarchaeological work, has taken an interpretive approach towards the technology. This work has shown the importance of non-technical, symbolic aspects of iron technology, exploring the role it can play in social differentiation, political and religious ideology and cosmology. A number of scholars have used ethnoarchaeological work in Africa to explore similar themes in early European ironworking (e.g. Hingley 1997; Bergstøl 2000; Haaland et al. 2002; Gansum 2004; Haaland 2004; Hingley 2005; Barndon 2006; Haaland 2006; Giles 2007b). Other studies have taken more traditional regional and technical approaches (Sim 1998; Schrüfer-Kolb 1999; Joosten 2004; Schrüfer-Kolb 2004), while others have approached iron technology from the perspective of landscape archaeology (e.g. Millett and Halkon 1988; Halkon 1995; 1997; Halkon and Millett 2000; Halkon 2007). While new approaches have flourished in recent times, the traditional technical, methodological and experimental studies have continued alongside, with recent edited volumes demonstrating the variety of approaches being taken (cf. Benoit and Fluzin 1995; Crew and Crew 1995; Magnusson 1995b; 1995a; Crew and Crew 1997; Nørbach 1997a; Feugère and Guštin 2000; Tizzoni and Tizzoni 2000; Nørbach 2003).

Research on Iron in Ireland

Interest in ancient iron in Ireland has fluctuated throughout the history of archaeological study in Ireland, with very few specialised researchers studying the material. There has, however, been a steady stream of excavations with ironworking remains, though the level of attention paid to these has generally been low. Scott (1990, 1) dates the beginnings of interest in the history of iron technology in Ireland to the nineteenth century AD and the chemical analysis of a few swords from the Viking burials in Kilmainham, Co. Dublin (Mallett 1853). This antiquarian interest was later succeeded by scientific examinations of artefacts and slag from a number of
sites excavated following the foundation of the Irish Free State in 1922. Analysis of iron artefacts was uncommon but did occur (e.g. Evans 1935; 1937; 1948), while the analysis of industrial residues including slag and ore was more frequent (e.g. Childe 1936; Gaffikin and Davies 1938; Ó'Riordáin 1940; Proudfoot 1953; Collins 1955), including a series of analyses carried out by J. Cecil Maby on sites excavated by the Harvard expedition to Ireland (Hencken 1938; 1942; 1950). Following the Second World War, the work of M. J. O'Kelly marked the beginning of focused research into ancient Irish iron technology. O'Kelly's interest in ironworking began with his excavations at Garryduff 1, (IID:103; O'Kelly 1946; 1963) and St. Gobnet's House (IID:186; O'Kelly 1952), both in Co. Cork, where his ‘dissatisfaction with the interpretations’ given in his report led to broader research into ironworking technology (O'Kelly 1963, 102). This research continued in the 1950s, coinciding with the discovery of ironworking remains at Beginish, Co. Kerry (O'Kelly 1954-56; not included in this study due to a lack of dating evidence), Church Island, Co Kerry (IID:053; O'Kelly 1958), and Knockea Co. Limerick (IID:133; O'Kelly 1967). O'Kelly conducted some of the earliest iron-smelting experiments in Europe and his preliminary report indicates they were quite extensive, investigating tuyere shapes, furnace shapes and air delivery systems (O'Kelly 1961), though unfortunately the experiments were never fully published. Besides this, iron production was treated as just one of a number of craft/industrial activities, rarely discussed in great detail and never the focus of excavation. Research in this period of Irish archaeology was empiricist and culture-historical, focused on data-gathering and explaining change through migration and diffusion, and iron technology was understood in the context of this historical view of the past (cf. Cooney 1995; Waddell 2005).

The development of processual archaeology brought a focus on new scientific techniques and a more rigorous approach to data in Irish archaeology (Cooney 1995, 270). By the 1970s Brian Scott had succeeded M. J. O'Kelly as the only scholar with an active interest in iron technology. His main interest was the metallography of iron artefacts (Scott 1971a; 1974a; 1976a; 1977; 1978a; 1981c; 1989b), though he also published extensively on evidence for iron technology in early Irish texts (1981a; 1981b; 1982; 1983b; 1983a; 1987; 1988; 1989a). His work culminated in the publication of *Early Irish Ironworking* (Scott 1990), a synthetic review of the history of iron technology in Ireland in the Iron Age and early medieval periods, the same time-span covered in this study. Scott took a formalist approach: understanding early iron ‘industries’ through the terminology and ideas derived from capitalist economics such as the ‘profit motive’ (Scott 1990, 29; Geselowitz 1992, 225; Tierney 1998, 197-198). While Scott was able to draw on evidence from quite a large number of sites, he found significant gaps in the excavated data relating to all of the main stages of iron production, with particularly serious
deficiencies in the recording of ironworking features and assemblages of ironworking debris (Scott 1990, 214-218). Excavation reports from the period often mention evidence for iron production but very few include scientific analyses or even basic descriptions of the material (although see Harper 1972; Fanning 1981; Brannon 1981-2; Gaskell-Brown and Harper 1984; Williams 1986 for some exceptions).

The decade following the publication of Early Irish Ironworking saw minimal research focused on ironworking. Some metallographic analysis was carried out (Hall 1991; 1992; 1995) and Scott’s work was incorporated into broader syntheses of the Iron Age and early medieval periods (Edwards 1990, 86-90; Mytum 1992, 229-236; Raftery 1994, 147-150; Waddell 1998, 283-286). There was some improvement in the reporting of ironworking debris from a few sites excavated in the period (e.g. Keane 1995; Swan 1995; Crew and Rehren 2002) though many published reports provided only cursory information (e.g. Ó’Riordáin et al. 1997; Keeley 1999; Mount 1999). However, the last ten years have seen significant changes in how ironworking debris has been recorded and reported. Large-scale excavations, significant funding and the discovery of sites with extensive iron production evidence have led to the relatively common production of specialist reports on ironworking material (e.g. Fairburn 2003; Keys 2006; Kearns 2007; Anguilano 2008; Cruickshanks and McLaren 2009; Martinón-Torres 2009; Photos-Jones 2009; Wallace 2009a; Scully 2010; Young 2010). Much of the information presented in these reports remains unpublished, though in some cases they have been made available on CDs accompanying excavation monographs (e.g. Carlin et al. 2008a; Johnston et al. 2008; Gillespie and Kerrigan 2010). The extensive primary research which has produced these reports has begun to reach publication through integration with excavation reports (e.g. Clarke and Carlin 2008; Clarke 2010; Gillespie 2010). Some more generalised discussions of ironworking technology have appeared, though they are generally empirical presentations of data and technical examinations (e.g. Dowd and Fairburn 2005; Fairburn 2008; Wallace and Anguilano 2010b). Carlin et al. (2008b) went further as part of a synthesis of the ironworking evidence from sites along the route of the M4 motorway, examining the evidence for specialisation through an analysis of the contexts of iron production and comparison with evidence from historical texts. What has been lacking in many recent publications is an awareness of the broader picture of ironworking in Ireland, due largely to the very recent nature of many relevant excavations. There has also been an understandable impetus to process and make available the large amount of data produced in the last decade. This has restricted the possibilities for synthetic reviews and the re-interpretation of Irish iron technology. This study attempts to rectify this situation through a complete review of both the published and unpublished evidence for ironworking recovered in Ireland to date.
Methodology

One of the primary aims of this study is to provide a comprehensive review of the archaeology of iron production in Ireland, building on Scott’s (1990) earlier synthesis. For this reason the geographic scope of the project was broad from the outset. The project also has a relatively wide chronological span: from the beginning of the Iron Age in the first half of the first millennium BC to the end of the ninth century AD. This is essentially the same period covered by Scott (1990, 8-9) and was selected for the same reasons: to avoid any significant overlap with the introduction of Scandinavian iron technology following the establishment of the first Norse settlements in the ninth century AD (e.g. Stillman et al. 2003; Wallace 2005).

In summary (see Chapter 4 for detailed discussion), the dataset for this study encompasses all sites in Ireland dating to the study period with evidence for in situ smithing or smelting. This was almost invariably in the form of slag assemblages, often associated with features, structures, other artefacts and materials such as ore, charcoal and fired clay. Data collection involved an extensive review of the published literature, online databases of excavation, as well as direct contact with individual archaeologists and archaeological companies. Information from published and unpublished sources was entered into a project database constructed in Microsoft Access 2007 and linked to a Geographical Information System (GIS). This facilitated collation and interrogation of the data as well as spatial analysis through the production of maps within the GIS. The final database, which is discussed in detail in Chapter 4, includes 202 individual sites (Figs 1.1-1.4 and Table 1.1), each with a unique numerical identifier preceded by the abbreviation ‘IID’ (Irish Iron Database), which is used throughout the text to indicate precisely the site being discussed and to aid examination of the site entry in the project database/appendices, e.g. Adamstown 1, Co. Waterford (IID:001). The addition of sites to the database ceased in June 2010 and excavations and publications post-dating this could not always be incorporated into the study. Data from individual sites is quite variable but overall there is enough good quality evidence to allow a detailed characterisation of the archaeological remains of iron technology.

Data in the project database is drawn from published site reports as well as a significant number of unpublished preliminary/interim and final excavation reports. The unpublished reports are generally of a very high standard and include in-depth discussion of stratigraphy, detailed descriptions of individual features, fills and artefacts as well as specialist reports on scientific dating, slag analysis, finds analysis, environmental analysis etc. As re-evaluation of specialist archaeometallurgical reports was to be a key part of the research, a semester of
study in the Institute of Archaeology, University College London under Prof. Thilo Rehren and Dr. Marcos Martinon-Torres was undertaken in 2008. This included archaeometallurgical training and the scientific analysis of slag from two Irish settlement sites: Mackney (IID:149; Delaney 2009a) and Loughbown (Bower 2009; not included in the study as the ironworking dated between the tenth and thirteenth centuries AD), both in Co. Galway (reports on both sites are included in Appendix 1: Dolan 2008a; 2008b). This training was key to the reassessment of Irish iron technology detailed in Chapters 5 and 6.

Theoretical Approach

The second objective of the project is to contribute to our understanding of the social context of iron technology in Ireland. The idea of technology as a social phenomenon is rooted in an anthropological conception of technology as a social construct that combines the material and symbolic (cf. Lemonnier 1986; Pfaffenberger 1988; Ingold 1990; Pfaffenberger 1992; Lemonnier 1993; Dobres and Hoffman 1994; Budd and Taylor 1995; Sillar and Tite 2000; Dobres 2010; Conneller 2011). This does not see technology as a separate, autonomous force acting on society but rather as a product of people’s choices, forming part of a complex web of interdependent social relationships. At the same time, technology is ‘materially grounded’ and its materiality and underlying technical rules, identified through empirical study, form the basis of an understanding of the social dynamics of technology (Dobres and Hoffman 1994, 214). This social view of technology builds on the evolutionary view of iron technology popularised by Childe (1944), which saw metallurgical technologies as naturally progressing through stages in a rational, scientific and evolutionary model. It argues against a focus on economic explanations of technological organisation and change which treats technology as an industry, driven by capitalist market forces (e.g. Scott 1990; Cleere and Crossley 1995), though that is not to say that early ironworkers were not motivated by material gain. It is likely, particularly in non-literate societies (e.g. Iron Age Ireland), that the magico-religious aspects of iron technology: the social activities carried out as part of iron production that can be described as ‘ritual’ or ‘symbolic’ would have been particularly important (Budd and Taylor 1995, 139).

Ethnographic studies in traditional iron-using communities strongly support a view of iron technology as socially embedded and actively used by individuals and groups within society to create and maintain their social worlds, through its place in power-relations, religion, ritual and cosmology. For example, in a discussion of the social contexts of iron production in Karagwe, a nineteenth century AD kingdom located in what is now Tanzania, Reid and Maclean (1995) illustrate the symbolic as well as the political role iron technology can play. In Karagwe, iron smelting was seen as a metaphor for procreation and fertility and was accompanied by
rituals such as the use of ‘medicines’ to encourage a successful smelt and the exclusion of fertile women who posed a danger to the process. The men who carried out smelts belonged to clans whose identities were derived from their specialised ritual and practical knowledge of smelting. This knowledge, as well as a cosmological view of iron smelting as a dangerous rite associated with fertility (and infertility) and thus as a danger to the fecundity of the state, made these clans both powerful and dangerous. The king of Karagwe was also symbolically associated with ironworking, though with the less dangerous practice of smithing, and he used coronation rituals and other techniques to control smelting groups who possessed secret and dangerous knowledge. Similar examples of the important role of iron technology in society in terms of power relations, gender, magic and ritual can be pointed to elsewhere in Africa (e.g. Herbert 1993; Schmidt 1997; Barndon 2004) and while the social context of traditional iron production in Africa cannot be simply mapped onto prehistoric and early medieval iron production in Ireland, these examples do demonstrate clearly the extent to which iron technology can influence the society that uses it.

Haaland (2006), drawing on ethnographic work as well as European folklore has proposed that metaphorical associations between iron technology and transformational processes, such as ore to iron, fertility and rites of passage, as well as the dual productive/destructive role of the smith who creates both weapons and tools, may be to some extent universal. Giles (2007b) has applied some of these ideas about the symbolic potential of iron technology to the British Iron Age, arguing that the introduction of iron technology and the new metaphorical connections it allowed made possible new ways of thinking about social relations. Metaphors in this context are ideas that are embedded in material culture; in this way objects can come to stand for social relationships and can guide people into seeing the world in particular ways (Tilley 1999; Williams 2003, 224-229; Giles 2007b, 399-400). Giles (2007b, 409) argues that iron technology in Iron Age Britain was ‘a rich source domain for metaphors linked to transformative power’ with smelting linked particularly to fertility, and smithing providing metaphors relating to leadership and authority. These are useful ways of thinking about how iron and iron technology could have been conceived but there is some danger in translating metaphorical associations from vastly different places and times. Nevertheless, there is no doubt that iron technology and iron itself would have been a rich source of metaphor, much as it is today.

The metaphorical association of the ‘skilled crafting’ (Giles 2007b, 406-407) of smiths with authority and performance may be a particularly useful approach when thinking about craft specialisation. The concept of craft specialisation in the iron industry of Iron Age Britain and its
implications for social organisation have been explored by Ehrenreich (1991b; 1995) who, following Arnold (1987) and Michaels (1989), identified craft specialisation through the presence of surplus products, dedicated workshop areas, evidence for the export of products and the standardisation of production methods. He argued, using these criteria, that the presence of specialist smiths operating in a hierarchical system could not be supported, suggesting instead a heterarchical model for the society, although the concept of ‘standardisation’ of technology, is a notion that seems inappropriate for the small-scale industries of prehistory (cf. Budd and Taylor 1995, 137). Recent understandings of craft specialisation have moved away from the idea that it is an activity with the sole goal of producing a surplus for a market, acknowledging the issues of power, inequality, ideology and social identity caught up in craft production (cf. Schortman and Urban 2004). Craft specialisation is defined here simply as the production of items in volumes in excess of individual or group needs, but these volumes need not have been large, and there may have been many reasons for their creation. Smiths and smelters, the practitioners of a socially embedded and symbolic technology, could also perform other functions: ritual specialists, landowners, outcasts, authority figures, even political leaders. As Giles (2007b) argues, it is in these capacities that ‘skilled crafting’, the practice of iron technology and the display of secret knowledge, may have been important in creating and maintaining the power and identity of iron specialists.

One interesting element of iron technology is its dispersed nature and the possibilities for wide variation in participants, specialisations and location at various stages (Ehrenreich 1991b, 69). Different processes may have taken place at various places in the landscape and may have involved disparate individuals and groups with varying social roles and status. The ability to identify different stages of production in specific places in the landscape provides opportunities for looking at the landscape context of the tasks involved in iron production. Landscape is taken here, not as a passive, neutral, resource-filled environment (e.g. Clarke 1972; Evans 1973) but rather as a primarily social concept which is created (cf. Ingold 1993; Tilley 1994; Schama 1995; Bender 1998; Cooney 1999). In this view, iron technology took place in landscapes filled with social meaning; decisions about where and when to undertake processes such as ore gathering, charcoal production, smelting and smithing would have been contingent not only on issues of labour, resources and time but also other social pressures and proscriptions such as taboos, warfare and political or religious authority. Through an examination of the landscape context of these processes it may be possible to connect iron production with other social spheres, identifying connections which may have been important in the past.
In summary, this study utilises a variety of methodological approaches, beginning with an empirical and technical analysis of the dataset of ironworking in Ireland from the Iron Age to the early medieval period, in order to establish an understanding of the technological processes evident on individual sites as well as a broader characterisation of the archaeological evidence for iron technology in Ireland during the study period. The study views iron technology as socially embedded, influenced by and influencing society through the technological choices made by those engaged with iron. It draws on ethnographic parallels which stress the social element of iron technology, in particular its rich symbolic and magico-religious potential. An important strand is the concept of craft specialisation which is seen here as an indicator of the existence of specialists creating products surplus to their own or their group’s requirements, whether that be in large or small quantities, and for whatever social functions. Another key approach is the examination of iron technology within the landscape, assessing the places in which various ironworking processes were carried out in order to understand the place of iron technology within other social spheres.

Structure

The structure of this thesis is as follows. The following two chapters review technical aspects of iron production, with a particular focus on the traces left by such processes in the archaeological record. Chapter 2 focuses on bloomery ironworking, discussing current understandings of smelting and smithing processes and the features and artefacts associated with them. Chapter 3 focuses on the key materials required for smelting and smithing: ore and fuel. Chapter 4 discusses in detail the design and rationale behind the project database. It also includes a detailed analysis of the quality of the data recorded in the database, considering potential issues and biases created by source materials, the database and other factors. Chapters 5 and 6 review the archaeological evidence for iron production recorded in the database through in-depth discussion, characterisation and comparative analysis of features such as furnaces and hearths as well as associated finds and structures. A case-study focused on Iron Age iron production in the midlands is presented in Chapter 7. This case-study starts off with a general review of the archaeology of the region and understandings of the Iron Age in Ireland. The introduction and development of iron technology in the area is then considered as well as the landscape and social context of smithing and smelting. Chapter 8 focuses on a thematic case-study looking at evidence for specialist ironworkers in the early medieval period in Ireland. The evidence for specialists in different spheres of life is reviewed before a chronological outline of changes in the scale and organisation of the early medieval iron
industry is given. The chapter concludes with a discussion of iron specialists in early medieval society. Finally, Chapter 9 briefly reviews the aims, objectives and research questions put forward in the first chapter, considering to what extent the project has been successful and proposing avenues for future research. Volume 2 includes two scientific reports produced during research for the project, a report on experimental work, as well as all figures, tables and maps referred to throughout Volume 1. It also contains three appendices which summarise the information collected for the project database.
2. **Smelter and Smith: The Technology of Bloomery Iron**

A large amount of research has been carried out on the technical aspects of iron technology: the mechanics of what goes on within smelting furnaces and smithing hearths and the processes which generate archaeologically visible material including iron and steel, slag, vitrified clay and other debris (e.g. Tylecote 1962a; 1976; Clarke 1979; McDonnell 1983; Tylecote 1986; Tylecote and Gilmour 1986; McDonnell 1987b; Tylecote 1987; McDonnell 1988a; 1988b; 1991; 1995; Mack *et al.* 2000; Pleiner 2000; Joosten 2004; Buchwald 2005; Pleiner 2006; Charlton 2007). This discussion does not focus on the chemical and thermodynamic processes of iron metallurgy, though these will be briefly outlined, but rather on the material remains associated with the various stages of iron production.

The iron weapons and tools that spread through Europe in the Late Bronze Age were produced in two main phases. First a ‘bloom’ – an unrefined mass of iron/steel and slag – was smelted within a ‘bloomery’ furnace. The bloom was then processed through hammering (smithing), first into a relatively pure billet and then into a finished item. The two main stages will be dealt with separately in this chapter, though they will occasionally be referred to collectively as ‘ironworking’. Similarly, while both iron and steel – an alloy of iron and carbon with varying physical properties – can be produced within a bloomery furnace and through case-hardening in a smithing hearth, the generic term iron is used here to refer to both, except where the distinction is relevant. A consideration of the various problems involved in interpreting archaeological evidence for early ironworking, along with a familiarity with the technical aspects of the technology are crucial to the critical analysis of the data presented here and interpreted in subsequent chapters.

**The Smelting Process**

All smelting in Europe prior to the medieval period was carried out using the direct or bloomery process (McDonnell 1995, 3). Smelting using the direct process took place in bloomery furnaces which could vary in design but essentially acted as insulated vessels within
which the chemical processes required for the formation of iron from ore could take place (McDonnell 2001, 501). The basic theory behind the bloomery process is straightforward, though it is complicated by the multifarious conditions and materials that can influence the process. It has been discussed extensively in the literature (e.g. Percy 1864; Tylecote et al. 1971; Tylecote 1976; Serling 1979; Killick and Gordon 1988; Craddock 1995; Pleiner 2000; Joosten 2004; Buchwald 2005; Charlton 2007), but the huge variation in furnace types, fuels, ore and practices demonstrable in the ethnographic and archaeological record mean the exact conditions within a furnace can vary considerably. Fundamentally, smelting involves the intentional reduction of a metallic element from the various gangue (waste) constituents in its ore through a thermo-chemical process. When smelting iron using the bloomery process, two key parameters need to be achieved: a sufficiently reducing atmosphere and sufficient heat to feed the endothermic reduction process and facilitate the formation of a liquid slag. Reduction of the ore – the removal of the oxygen from the iron (hydr)oxide – requires an atmosphere which is oxygen deficient and a reducing gas, usually carbon monoxide (CO) generated by a reaction of carbon from the fuel with the limited oxygen (McDonnell 2001, 495). All bloomery furnaces – no matter what their form – will have zones of varying temperature and atmosphere where different processes take place. These conditions are dynamic within the furnace and through the course of the smelt (see Fig. 2.1 for a schematic version of these processes). The ore is initially oxidised as it travels through the furnace (or is oxidised prior to this through roasting in an open fire). When it reaches a temperature of c. 500°C it can begin to reduce through the following series of reactions (cf. Pleiner 2000, 133-136; Joosten 2004, 7-10; Charlton 2007, 88-95):

\[
\begin{align*}
3\text{Fe}_2\text{O}_3 + \text{CO} & \rightarrow 2\text{Fe}_3\text{O}_4 + \text{CO}_2 \\
\text{Fe}_2\text{O}_4 + \text{CO} & \rightarrow 3\text{FeO} + \text{CO}_2 \\
\text{FeO} + \text{CO} & \rightarrow \text{Fe} + \text{CO}_2
\end{align*}
\]

As the temperature increases towards c. 800 - 1000°C and higher, direct reduction of the iron oxide through reaction with solid carbon can take place:

\[
\begin{align*}
\text{Fe}_3\text{O}_4 + 4\text{C} & \rightarrow 3\text{Fe} + 4\text{CO} \\
\text{FeO} + \text{C} & \rightarrow \text{Fe} + \text{CO}
\end{align*}
\]

At this stage the iron, while reduced, has not been separated from the gangue in the ore and it requires a temperature of c. 1100°C – 1200°C for a liquid slag to form. This is made up
primarily of partially reduced iron (wüstite, FeO) and silica, generally derived from the gangue (SiO$_2$):

$$2\text{FeO} + \text{SiO}_2 \rightarrow \text{Fe}_2\text{SiO}_4$$

The resulting compound is fayalite ($\text{Fe}_2\text{SiO}_4$), the main constituent of iron slag, which melts and largely runs away from the reduced metallic iron leaving a spongy bloom of iron and some slag. A large proportion of the iron in the ore is taken up as a flux in the slag, making the bloomery process self-fluxing (Craddock 1995, 244). However, other oxides such as calcium oxide and manganese oxide could be added as fluxes to reduce both the melting temperature of the slag and the amount of iron used, thus increasing the efficiency and yield of the smelt (e.g. Joosten 2004, 63-66; Charlton 2007, 93). The slag is crucial as it carries away other gangue materials, allows the agglomeration of the metallic iron and also protects it from re-oxidising when it reaches the combustion zone where a high-oxygen air blast is fed in through the tuyere. The bloom generally accumulates just below, and attached to the tuyere, although with high blowing rates it is possible for it to form more centrally and lower down in the furnace (Sauder and Williams 2002).

The orthodoxy that bloomery iron is almost always pure ferrite or very low in carbon and is formed in a solid-state process – below the melting point of pure iron – with a fluid slag at about 1200°C (e.g. Tylecote 1986, 128-129) has been challenged, and some researchers (e.g. Bjorkenstam 1985; Rehder 1986) contend that parts of the furnace can regularly have temperatures as high as 1400°C forming liquid cast iron (iron with between 2 and 5 wt% carbon and a lowered melting point between 1150°C to 1200°C; Craddock 1995, 236) which is decarburised (carbon content is reduced) when it moves through the oxidising combustion zone (see Pleiner 2000, 132 for a summary of the debate). Mack et al. (2000) argue that cast iron was being deliberately produced in Anglo-Saxon bloomery furnaces and subsequently being decarburised by the eighth or ninth century A.D. and possibly earlier.

Whether iron was produced in the solid state or not is not particularly significant for this study, but the question of carbon content in a bloom and the extent to which it could be controlled by early smelters is very important. Iron only became truly more functional than bronze for tools and weapons when alloyed with carbon to form steel, a far stronger and harder material (Wheeler and Maddin 1980, 124). Iron-carbon alloys vary considerably in their properties with very low-carbon wrought iron being highly malleable but soft, steel (with a carbon content generally below 1 wt% and always below 2 wt%) being stronger and harder, and cast iron
(between 2 and 5 wt% carbon) being very hard but so brittle that it is not forgeable without decarburisation (Craddock 1995, 236). Another important material which can enter into bloomery iron from the ore during a smelt is phosphorous, an element which makes iron brittle but hard and gives a bright white sheen that contrasts with duller carburized iron (Godfrey et al. 2003, 170-178; Buchwald 2005, 180). Carbon and phosphorous can exist together in a bloom (e.g. Salter and Crew 1997) and will cause varying, sometimes beneficial, effects (e.g. increased hardness) depending on amounts and the subsequent working of the iron/steel (Tylecote 1986, 144-146; Tylecote and Gilmour 1986, 7-9; Craddock 1995, 238-239). Sulphur can also enter the metal from the ore or from coal but it has a detrimental effect, making the metal brittle at high temperatures, and cannot be worked (Tylecote 1986, 127-128).

It is likely that the varying properties of iron from different ore would have been recognised empirically by early ironworkers. Iron made from different ore (e.g. high-phosphorous bog ore) or using different smelting techniques would have exhibited different properties, recommending them for use in different applications (e.g. the use of phosphoric iron for traditional wire drawing; Goodway and Fisher 1988). Even blooms from single smelts could have carbon dispersed heterogeneously, resulting in harder and softer iron in different parts of the bloom (Salter and Crew 1997). Iron with different properties could be combined into composite artefacts, combining for example hardness at a cutting edge with ductile strength elsewhere (see smithing section below).

**Smelting Furnaces**

Smelting sites are difficult to characterise as they are often open-air and can occur almost anywhere in the landscape provided there is access to ore and fuel. The primary identifiers of a smelting site are smelting furnaces and smelting slag, both of which are discussed in detail below. Other features of smelting sites may include caches or deposits of ore or clay (for furnace/tuyere construction), evidence for ore preparation, or evidence for fuel storage or production (see Chapter 3 for discussion of fuels and ores used in smelting). Smithing may also occur alongside smelting. However, when attempting to identify smelting in the archaeological record the only unambiguously diagnostic feature is the iron smelting furnace.

Furnaces are essentially a development of open hearth and kiln technology (Charles 1980, 161-162). The addition of an enclosure of clay or stone around a fire allowed an increase in temperature, the use of charcoal made the fire smokeless and therefore approachable and
workable and finally the addition of a controllable draught made high-temperature metallurgical operations possible (Rehder 1986, 87). Iron smelting requires temperatures high enough for the reduction of ore (c. 800 °C) and to liquate the slag (over 1100 °C) as well as a strongly reducing atmosphere (McDonnell 2001, 501). This can be achieved in a variety of ways and this section will present the main furnace designs that have been identified both in the archaeological record and through ethnographic work (Fig. 2.2).

The enclosure of a furnace can be accomplished in any number of ways but a refractory (i.e. insulating) lining is almost always required. This is generally made primarily of clay, a material which would have been well known and understood through a long history of use in the production of pottery, figurines, technical ceramics and furnaces for bronze working. Surprisingly, there is very little discussion in the English-language archaeological literature about the make-up of the refractory linings and structures of iron smelting furnaces (although see Percy 1861, 208-215; Cleere 1971b, 209; Parr and Boyd 2002), though some work has been done in continental Europe (e.g. Bartuška and Pleiner 1965; Eschenlohr and Serneels 1991; Dunikowski and Cabboi 1995; summarised in Pleiner 2000, 257-258; Buchwald 2005, 225-229). This is despite the collection of materials, transportation and hand-mixing of fire-clays being an important part of the labour involved in constructing a furnace. There is rarely any explicit discussion of these materials in studies of ironworking or of the skills and energy expended in sourcing and mixing them. However, there would have been significant differences in the heat-resistance of different types of clay depending on their mineral content, and there is clear evidence for the use of different clay mixtures depending on the needs of particular ores and smelting styles (Pleiner 2000, 258).

Experimental work carried out as part of this PhD research, and discussions with members of the experimental archaeology group Umha Aois1 (2010) suggest that the mixing of materials such as sand, stone, grog, straw, grass and dung with clay would have been crucial to the success of a furnace structure, and that variations in mixture could have been used for different parts of the furnace and separate structures such as tuyeres and smithing hearths. Evidence for various methods of strengthening furnace walls using wood or wicker has been found archaeologically and ethnographically and incorporated into experiments (e.g. Serning 1979, 67; Brown 1995, 46; Gjerløff and Sørensen 1997, 67-68), and stones of various sizes could also be incorporated (e.g. Pleiner 2000, 179)

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1 See http://www.umha-aois.com/
The structure of a smelting furnace can take a myriad of shapes and sizes, and ethnographic evidence shows that while technical limitations of the smelting process and construction materials are important, designs and decorations can also incorporate a variety of features and decorations influenced by other cultural preferences (e.g. Burka 2008). This diversity of morphology and technology combined with the extreme rarity of preservation of above-ground elements of furnaces means that detailed classification of excavated furnace-types is difficult. Nonetheless, a large number of researchers have attempted to produce furnace typologies (e.g. Forbes 1950; Coghlan 1956; Cleere 1972b; Coghlan 1977; Martens 1978a; 1978b; Pleiner 1978; Serning 1978; Serning 1979; Tylecote 1986; Pleiner 2000; Paynter 2007a).

One of the most significant archaeologically identifiable differentiators between furnaces is how slag is dealt with (Cleere 1972b, 20-23). In order for a bloom of iron to form within the furnace, the waste material in the ore – in the form of slag – needs to flow away. Some furnace designs facilitate this through the ‘tapping’ off of fluid slag at intervals through a tapping arch in the furnace wall. Others provide a pit beneath the furnace superstructure into which the slag can drain, or simply hold the slag in the base of the furnace (McDonnell 2001, 501). These two broad types are termed tapping furnaces and non-tapping, or sometimes pit-furnaces.

**Bowl Furnace**

The bowl furnace is the simplest form of furnace possible for the smelting of iron. Essentially it is a bowl-shaped depression in the ground, or potentially raised above the ground (cf. Martens 1978b; Serning 1978; Dungworth Forthcoming), with a depth:width ratio below 1.0 and no provision for slag tapping. Early experimental work (Wynne and Tylecote 1958; O’Kelly 1961) indicated that it was a viable, if difficult and low-yield, method for smelting iron, tough to control without the use of some type of low superstructure. However, the unsuitability of bowl furnaces for producing blooms of significant size, combined with difficulties identifying them archaeologically and the existence of more sophisticated and efficient furnace designs throughout Europe from an early date led to a re-assessment of their existence in Iron Age Britain and Europe (Cleere 1972b, 23; Coghlan 1977, 25; Clough 1985; Tylecote 1986, 133) and, in Britain at least, most furnaces are now seen as variations on the shaft furnace (e.g. McDonnell 2001, 501). Early use of bowl furnaces, particularly in Ireland, has, however, been supported by some researchers (Scott 1990, 158-170; Pleiner 2000, 145-149; Photos-Jones 2008a). Dungworth (Forthcoming) following Clough (1986, 35-45) and Brown (1995) has argued that the bowl furnace may have been used in specific situations where very rich ores (c. 90% Fe) were smelted, leaving very little slag.
The bowl furnace has been crucial to understandings of Irish iron smelting technology since O’Kelly’s (1952; 1954-56; 1958; 1961; 1963) early experiments and excavations. Scott (1990, 159-160) recognised the limitations of bowl furnaces but concluded it was the primary furnace type in Ireland in the Iron Age and early medieval period based on the limited data available to him. Ironworking features with slag from sites in Ireland are still generally identified as bowl furnaces (e.g. Fredengren 2002, 237; Walsh and Harrison 2003, 35; Bowen 2006; Byrnes 2007; Dennehy 2007; Comber 2008, 115-117; Murphy 2008; Photos-Jones 2008a; Tierney 2008, 107; Delaney 2009b; McSparron and Williams 2009, 120; Bayley 2010), with some exceptions (e.g. Mytum 1992, 231; Crew and Rehren 2002, 96; Dowd and Fairburn 2005; Edwards 2005, 284-285; Carlin et al. 2008b, 91-93; Wallace and Anguilano 2010b). However, recent evidence, particularly the identification of furnaces with well-preserved superstructures at sites such as Derrinsallagh 4, Co. Laois (IID:077; Photos-Jones and Wilson 2007a; Young 2008a; Lennon 2009c) and Grange 2, Co. Meath (IID:108; Kelly 2011a; Wallace and Anguilano 2011) has put beyond doubt the early existence of more complex furnace designs (see Chapter 5 for in-depth discussion of this evidence). There is also good evidence for more complex furnaces being used to smelt copper in Bronze Age Ireland (O’Brien 2004) and it seems clear that most furnaces in Iron Age and early medieval Ireland were not bowl furnaces, paralleling the situation in Britain, Scandinavia and western Europe from the Iron Age on.

There are occasional references in the literature to a particular bowl furnace form lined with stone; these are usually found in Scandanavia. In Norway, these are termed hellegryte or hållgrytor and were first identified by Hauge (1946), and later at Møsstrond in Telemark where Martens (1988) split them into two types: with and without a provision for slag tapping (Serning 1979, 74-76; Pleiner 2000, 148; Buchwald 2005, 90). Those without tapping channels were seen as a type of open bowl furnace with air being blown in from the top (Fig. 2.3). More recently Espelund (2006) has argued, based on analysis of slag from Sjøholt in western Norway and the existence of far more efficient shaft-furnace designs in Norway centuries before the mid-first millennium A.D. dates from Telemark (Martens 1988), that the previous model of inefficient smelting in an open furnace does not stand up to scrutiny. He suggests the pits were used as a type of roasting pit, creating a semi-product that was smelted in furnaces at separate locations. This alternative use for such pits is not universally accepted (cf. Loftsgarden 2007, 23-25) and similar stone- (sometimes together with wood-) lined pits have been found under quite sophisticated slag-tapping shaft furnaces in Gråfjell in eastern Norway where they clearly did not function as tapping pits (Rundberget 2007; Larsen and Rundberget 2009; Rundberget 2009).
Domed Furnace

Domed furnaces are known from central Europe, where they date from the middle Iron Age to the second century AD (Joosten 2004, 13). They can be oval or circular in plan and are thought to have had domed superstructures covering a relatively large (1-1.2 metre long), flat or slightly hollowed hearth floor, often with multiple air inlets (Cleere 1972b, 11-15; Pleiner 2000, 163-172). The position of the hearth above ground would have made slag-tapping a possibility although there are no indications that this was done (Joosten 2004, 13). The superstructure, which would have had an opening at the top, allowed the progressive feeding of fuel and ore, as well as minimising heat loss and facilitating a larger reduction zone (Pleiner 2000, 163-172). Where multiple air inlets were used, more than one reduction zone could have been maintained allowing the production of a number of blooms (Joosten 2004, 13). Domed furnaces could be free-standing or built into an embankment or wall.

The definite archaeological identification of a domed furnace relies partly on the plan of the feature but also on the survival of a sufficient amount of superstructure. The extent to which a superstructure must be curved to constitute a domed furnace is not clear from the literature. Martens (1978b) suggested a system of ratios to classify bowl, domed and shaft furnaces but this is impractical in archaeological contexts where preservation is such that height:width ratios are unknown. Nonetheless, domed furnaces do seem to form a distinct category in both time and space, mostly dating to the La Tène period in western and southern-central Europe and Britain (Pleiner 2000, 163). Previous to this study, no domed furnaces have been identified from Ireland.

Shaft Furnace

Shaft furnaces are essentially furnaces equipped with a cylindrical or conical (rather than domed) chimney or superstructure. When the chimney height is below c. 150cm they are sometimes called low-shaft furnaces (Serning 1978, 43). It is probable that variations on the shaft furnace were standard in Europe from the Iron Age on (Clough 1985). They can be separated into two broad categories based on the method used to deal with slag: slag-pit and slag-tapping furnaces. Shaft furnaces have only recently been recognised in the Irish archaeological record (Dowd and Fairburn 2005; Carlin et al. 2008b; Wallace and Anguilano 2010b).

Slag-pit

Slag-pit furnaces are widely known throughout Europe (Pleiner 2000, 149-163). Their defining feature is the provision of a pit under the shaft, where slag drained during the smelting
process. The pit could be bowl-shaped or flat-bottomed and could have tapering or straight walls. It is suggested that it would normally be packed with organic material such as wood or straw, which kept the pit clear of charcoal long enough for the slag to drain into it (Mikkelsen 1997; Pleiner 2000, 149). This packing can result in archaeologically diagnostic slag blocks, but these are not found in all cases (see discussion in slag section below). The pit could be lined with clay, sometimes connected to the shaft above (Joosten 2004, 13). In some instances the shaft could have been re-usable and could have been moved over a new pit for every smelt (Tylecote 1986, 136; e.g. Buchwald 2005, 150; Mihok 2006, 181). Pits could also have been cleared out, either with the shaft in situ from above or through an opening or arch in its side, or with the shaft fully or partially dismantled (Henderson 2000a, 228; Joosten 2004, 13-14).

**Slag-tapping**

Slag-tapping shaft furnaces are defined by their ability to extract molten slag from the furnace during the smelting process (Cleere 1972b, 20-23). This is advantageous, as the shaft does not fill with slag, meaning that the furnace can be worked for a longer period and produce a bigger bloom. They generally have a flat or slightly hollowed hearth, and always have an arch at the base of the furnace through which the slag can be tapped at particular points during a smelt (Joosten 2004, 15).

**Dug-in Furnace**

Dug-in or embanked furnaces were highly variable in shape and approach (Pleiner 2000, 176-179; Joosten 2004, 13). The type refers to furnaces built into walls, slopes, terraces or pits which had one open face (Fig. 2.2). Their design often results in part of the furnace shaft being preserved underground (e.g. Tylecote 1962b; Hall 2008), unlike free-standing shaft or domed furnaces. Dug-in furnaces exist with and without provision for slag tapping and can use natural or forced draught (Joosten 2004, 13). They can be partially or completely ‘dug-in’; i.e. they may also have a free-standing superstructure above the dug-in portion of the furnace (Pleiner 2000, 176-179). No dug-in furnaces have been published from Ireland but possible examples have been identified in this study (see Chapter 5).

**Air Supply**

The method of supplying air to a furnace is a very important element of smelting technology although unfortunately it is rare that much evidence for it survives. There are two main methods: natural draught or forced draught (Cleere 1972b). Natural draught encompasses wind-blown furnaces and induced draught furnaces which take advantage of the chimney effect (Craddock 1995, 174-177), while forced draught furnaces are blown using bellows
(Pleiner 2000, 196-205). The evidence for wind-blown furnaces in ancient Europe is very uncertain, based primarily on the positioning of furnaces at the tops of slopes facing into prevailing winds (Pleiner 2000, 196). Induced draft furnaces would have required long shafts but these are extremely difficult to recognise archaeologically (Pleiner 2000, 197). Wind-blown furnaces are known from Sri Lanka (Juleff 1995; 1996), but they relied on dependable and predictable monsoon winds which blow consistently from the west during July and August every year and have no direct equivalent in Europe (Craddock 1995, 175).

While bowl furnaces could only have functioned using a forced draught (Coghlan 1977, 23), furnaces with basal openings and tall superstructures could in theory have used natural draft. It is not clear archaeologically to what extent either was used, though in Europe it is generally assumed a forced draught was used, produced by a bellows of some form (Pleiner 2000, 198-205; Joosten 2004, 15). Depictions of bellows – made from organic materials that do not survive archaeologically – suggest the earliest type in Europe was the bag bellows followed by the concertina bellows in the Roman period, though both types would have continued in use (Pleiner 2000, 212-214).

Bellows would often have been used in conjunction with tuyeres – nozzles made of clay or stone – which would have insulated the bellows from the heat of the furnace. These are relatively frequent finds on archaeological sites and can vary quite widely in shape and size with tubular, conical, block and disc shaped examples known (Pleiner 2000, 205-212). Often only the tip of the tuyere closest to the furnace or hearth survives, as it is fired by the heat of the furnace whereas the air-dried body of the tuyere disintegrates over time (Tylecote 1986, 142).

**Smelting Products**

**Bloom**

The primary product of the iron smelting process is the bloom. The raw (or unconsolidated) bloom incorporates significant amounts of unwanted slag and requires smithing to expel this and consolidate the iron within into one piece called a ‘billet’ (Tylecote 1986, 167). Pleiner (2000, 230-250) records more than 300 blooms from about 90 sites in Europe which date from the Late Bronze Age to the Medieval period. They are extremely rare finds on archaeological sites, probably reflecting their value to those producing them. The size and composition of the bloom is likely to have been very variable, depending on furnace technology, ore and individual smelting conditions with varying amounts of carbon, sulphur, phosphorous and
other elements (Tylecote 1986, 167-168; Salter and Crew 1997). Experimentally, blooms from bowl furnaces as light as a few hundred grams have been recorded (Wynne and Tylecote 1958), right up to blooms weighing as much as fourteen kilograms from shaft furnaces (Sauder and Williams 2002). Tylecote (1986, 211) saw a progression from very small blooms under a kilogram in the Iron Ages of Britain and Ireland rising to c. 15kg by the fourteenth century AD and substantially larger (89kg) with the introduction of water-powered hammers to the bloomery process by the 13th century (Tylecote 1986, 142).

Slag

Slags are the product of high-temperature processes but are not always related to metallurgy. Non-metallurgical slags can result from a huge variety of events including the burning of clay-built houses, funeral pyres, brick manufacture, lime kilns, pottery kilns, glassmaking and glazed stone production (Bachman 1982). Iron slags can provide varied information about the processes which created them including scales of working, furnace types, ore provenance and the types of ironworking taking place on a site (e.g. smelting or smithing), though their interpretation is not always straightforward (cf. Bachman 1982; McDonnell 1983; Tylecote 1986; Kresten 1987; Crew 1995a; McDonnell 1995; Serneels and Crew 1997; Pleiner 2000, 251-267; Joosten 2004, 16-18; Paynter 2006; Crew and Charlton 2007; Paynter 2007a).

Iron smelting slags are made up of a mixture of iron silicates such as fayalite (2FeO·SiO$_2$) as well as iron oxides including wüstit (FeO) and magnetite (Fe$_3$O$_4$), droplets of metallic iron are also common (Bachman 1982; Scott 1990, 155). The composition of smelting slag is dictated mainly by the ore smelted, but also by smaller contributions from the furnace lining, the tuyere and the fuel ash (Crew 2000). On sites where all or most of these variables are known, they can be used to estimate the iron yield of an industry by calculating the materials balance of the smelting technology (e.g. Kresten 1987; Joosten et al. 1998; Joosten and Kars 1999; Crew 2000; Joosten 2004; Crew and Charlton 2007). The understanding and modelling of slag compositions can also potentially be used to provenance ores (to varying levels of accuracy), or to identify the origin of artefacts through their slag inclusions (e.g. Hedges and Salter 1979; Salter 1982; Bullas 1995; Buchwald and Wivel 1998; Host-Madsen and Buchwald 1999; Coustures et al. 2003; Dillmann and L'Héritier 2007; Blakelock et al. 2009). However, these techniques have yet to be applied in an Irish context; they are complex and require a degree of on-site preservation that is rare in Ireland.

The most common technique used for the interpretation of smelting slag is macro-morphological analysis, essentially visual examination and characterisation of shape, weight,
magnetism etc. Studies using this technique are useful for interpreting the basic technologies being used on a particular site. However interpretations are generally based on the analyst’s subjective experience of working with slag, and published studies often have strong regional biases (McDonnell 1995, 5-6; Pleiner 2000, 257). This variety of experience and approach also comes through in the terminology for various types of slag used in the literature, often without clear explanation e.g. slag spheres, slag prills, fuel ash slag, fluxed lining slag, furnace slags, slag cakes, amorphous slag, cinder, tap slag, raked slag, slag runners, furnace bottoms.

Some smelting slags are characteristic of particular furnace types or technologies, but much of the slag from a given smelt is non-diagnostic, and some slag types can be produced through both smelting and smithing. ‘Lining slag’ is a highly siliceous slag which forms when the clay wall of the furnace is heated to a sufficient temperature to make it molten (McDonnell 1983, 82; Pleiner 2000, 257-259); when this incorporates a large amount of material from the fuel ash in the hearth it can be termed ‘fuel ash slag’ (McDonnell 1991; Crew 1996, 2). These slags can occur in any type of high-temperature hearth and are not necessarily diagnostic of metallurgy. McDonnell (1983; 1991) uses the term ‘cinder’ to describe a silica-rich slag that is intermediate between vitrified lining and a fayalitic iron-rich slag, and suggests this is associated with both smithing and smelting. Other types, including ‘amorphous slag’ and ‘raked slag’, are also associated with both smithing and smelting. Amorphous slags have no characteristic morphology, while raked slags are similar but have formed into contorted shapes or small irregular cakes due to being pulled out of the furnace or hearth when in a pasty state (Crew 1995a).

Pit-furnaces deal with slag by draining it into a hollow of varying depth below the furnace hearth (see above). This can lead to the formation of a ‘slag block’, a more or less solid lump of slag that forms in the slag-pit and fills it, taking on its shape (McDonnell 1983; Pleiner 2000, 259-261; Joosten 2004, 16). These are characteristic of smelting sites in Scandinavia and eastern Europe, where they range in weight from 15kg to massive blocks weighing as much as 420kg (Pleiner 2000, 259). Early slag-pit or sunken-hearth furnaces from the Iron Age in Britain did not form solid blocks filling their pits; in Britain these are only known from the post-Romano-British period (Crew 1995a). There is some evidence that British furnaces occasionally formed plano-convex ‘furnace bottoms’ or ‘slag cakes’ (referred to as furnace bottoms here) but it is difficult to find a clear definition of these in the literature (although see Paynter 2007a for a recent attempt). Crew (1991, 28) noted that normal smelts in the low-shaft furnaces used in his experimental smelts produced no slag that fitted the category. However, Paynter (2007a, 205) accepts them as ‘the most diagnostic slags from non-tapping furnaces’ and illustrates two
examples from England (Fig. 2.4). Dense furnace bottoms can also form in slag-tapping furnaces where they sometimes retain a lip where the slag had run into a channel for tapping (Crew 1995a, 258; Pleiner 2000), so some caution needs to be used when interpreting these forms (see Fig. 2.2).

Analytical work by Young (e.g. 2003c; 2005d; 2008a) suggests that large masses of slag, which could be termed ‘furnace bottoms’, did form during smelting, though not at the base of the furnaces (Young 2005d, 3), but rather further up, immediately below the bloom (Fig. 2.5). It seems that the slags which form in the pit or hearth of a non-tapping furnace can be quite heterogeneous and do not necessarily form a classic plano-convex shape, in which case they can simply be called ‘furnace slags’ (Crew 1995a). Non-tapped slags may take on the shape of the wall of the furnace where they are in contact with it, and archaeological and experimental evidence shows they frequently have impressions of the wood, charcoal, reeds, straw or other organic materials used to reserve a space for the slag in the furnace pit (Mikkelsen 1997; Pleiner 2000, 149). The recognition of classic furnace bottoms is also complicated by their similarity to smithing hearth cakes (SHCs) which are plano-convex slag cakes produced during smithing (Tylecote 1986, 133; Scott 1990, 155-156; see below for further discussion). In Ireland, plano-convex slag cakes are often reported as furnace bottoms and seen as evidence for smelting in bowl furnaces (e.g. O’Kelly 1963; Byrnes 2007). It now seems likely that the majority of these ‘furnace bottoms’ are in fact indicative of smithing.

Crew (1995a, 2) identifies another type of slag characteristic of smelting in non-tapping furnaces: slag prills. These are long, thin pieces of slag that formed in the furnace pit by dripping down from the hot zone between pieces of wood or other organic material (Fig. 2.6). Dungworth (Forthcoming) suggests that these may also be produced in bowl furnaces where ores with extremely high iron contents were being used. Crew (1995a, 3) also notes a type of slag which forms late in the smelt when the temperature is very high and internal flows of very hot slag reach the base of the (slag-pit) furnace before cooling. This can have a smooth lower surface with clay and/or stones attached which makes it very similar to tap slag; however it will make up a very small part of a slag assemblage from a non-tapping site (Crew 1995a).

Tap slag is diagnostic of slag-tapping furnaces and is very easily recognised through its characteristic ropy surface. The slag is tapped after a pool of molten slag builds up within the furnace, usually at intervals during a smelt, and it cools outside the furnace (McDonnell 1983, 81-82). It is generally tapped through thin channels into a pre-prepared shallow depression in front of the furnace leaving two distinct forms: slag runners and slag cakes (Crew 1995a, 3).
Slag runners consist of thin, elongated pieces formed when the slag cooled between the furnace and the slag pool. They often preserve the U- or V-shape of the channel in which they cooled. Slag cakes are formed when a pool of slag collects and cools outside the furnace. The slag is tapped at intervals and the separate runs can often be seen as layers in the cakes and runners (Crew 1995a, 3). Both types have a flowed surface texture – similar to lava – and the surface can be rippled or smooth depending on the speed at which the slag ran out of the furnace (Fig 2.7).

Iron smelting slags are reasonably well understood, but there are still a number of issues that can cause difficulties during interpretation. Perhaps the biggest is the sheer diversity of slag produced even within each individual smelt; inevitably this means a large range of slag excavated is not classifiable morphologically. Also, slag from a variety of different times and processes can be deposited together and post-depositional corrosion can transform morphologies (e.g. Young 2009d). These kinds of problems can be addressed through analysis of phase compositions as well as chemical analysis of appropriate samples to identify the processes from which slags originate (Bachman 1982, 8-9; Charlton 2007, 110). Contextual information from related features and artefacts on a site is also very important. Another problem is the potential for recycling of slag during the smelting process. This has been demonstrated in experimental work (Sauder and Williams 2002) and would mean that slag deposited from a smelting campaign would not represent each individual smelt, but rather the final smelting cycle. This practice would be extremely difficult to identify archaeologically and could result in underestimation of the scale of smelting carried out on a site.

**The Smithing Process**

The smelting of iron is a complex, labour intensive and time-consuming activity and it produces a bloom which, while valuable, is not immediately useful. The raw bloom requires varying degrees of working to transform it first into usable iron and then into the object(s) desired. These two steps are termed primary (bloom) smithing and secondary (black) smithing (Tylecote 1981, 42). A distinction between primary smithing and secondary smithing in the archaeological record is sometimes possible through close interpretation of contextual evidence as well as the specific products of smithing identified on a site. This section will briefly summarise the processes involved in smithing as well as the archaeological remains produced by them and associated with them.
Primary and Secondary Smithing

The product of a successful bloomery smelt is a raw bloom. This bloom requires consolidation – the large amount of slag incorporated in it must be removed and any separate or loosely sintered (bonded) clumps of iron need to be forged together. Primary smithing is very likely to have taken place as soon as the unconsolidated bloom was retrieved from the hot furnace, to take advantage of the high temperature achieved during the smelt, thus conserving both time and fuel. However, blooms could also be cooled and cold-sorted to separate the iron and slag before re-heating and consolidation (Pleiner 2000, 215). Experimental attempts at bloom smithing (e.g. Crew 1991; Sim 1998) have demonstrated the skill it requires, although Sim (1998, 18) noted that these skills could be mastered reasonably quickly when compared with the huge variety of techniques and skills involved in secondary smithing. Secondary smithing involves a very diverse range of skills depending on the complexity of the artefact being produced. Knowledge of these skills would have varied between individual smiths, in different places and at different times. The identification of particular techniques and skill levels in the archaeological record is very difficult and is not the focus of this study. However, the differentiation between smithing sites and smelting sites is often possible.

The first stage of bloom smithing involves the consolidation of the spongy, slag-filled bloom into a ‘billet’, a mass of welded iron which still has some slag entrapped, and then a ‘bar’ of iron with minimal slag inclusions (Crew 1991, 29). The initial stage of this process is extremely difficult and a careful balance of temperature is required: too hot and the slag runs off, taking unconsolidated pieces of iron; too cool and the bloom could shatter (Sim 1998, 11-12; Pleiner 2000, 215). Bloom smithing requires very high temperatures (c. 1200°C) at which the iron becomes plastic, can be welded, and the slag becomes molten (Pleiner 2000, 215). The process is made even more difficult due to the inefficiency of slag in conducting heat which may lead to frequent reheating of the bloom (Crew 1991, 29). The conditions can be judged through the colour of the heated iron, the sound of the hammer strikes and the feel of the iron through the hammer (Sim 1998, 17).

Secondary smithing is a very broad category including a wide range of skills and processes, from simple unskilled hammering and shaping to specialist pattern-welding by master craftsmen. Consolidated iron can be shaped through cold-working, i.e. shaping without reheating, using simple tools such as hammers and chisels. However, cold working for any length of time can make iron or steel very hard and brittle (Tylecote 1986, 163). This can be alleviated through annealing, heating the metal to temperatures between c. 600–950°C
(depending on the carbon content) and slowly cooling it (Pleiner 2006, 66). However, the primary method of shaping iron both now and in the past is hot-forming or hot-forging, which requires the capability to reheat iron to temperatures as high as 1200°C (Tylecote 1981, 42). Forging can incorporate a large variety of techniques including cutting, upsetting, drawing-down, shouldering, bending, rolling, twisting, splitting, piercing, forge welding, swaging, die-forging, planishing, sharpening, pointing, and shrinking-on (cf. Scott 1990, 21-26). Close examination of early iron artefacts shows that all of these techniques were known and used by early smiths (for a detailed survey see Pleiner 2006, 53-70).

Very accomplished ancient smiths would have been aware of the varying properties of individual pieces of iron and steel, and were able to produce composite objects, with hard cutting edges combined with softer, tougher bodies (Tylecote and Gilmour 1986; McDonnell 1989; Blakelock and McDonnell 2007). As mentioned above, steel and phosphoric iron can be substantially harder than pure iron; these could be produced in a bloomery furnace but iron and low-carbon steels could also be carburized (their carbon content increased) in the smith’s hearth. The process of carburisation involves heating iron in close contact with charcoal (the source of carbon) for many hours (Craddock 1995, 252-253). The result is a layer of steel penetrating the surface of the iron to varying depths, depending on the duration of the process and the temperature sustained (cf. Tylecote 1981, 45). The properties of steel can be further affected through heating and quenching the steel. This has the effect of making it hard and brittle, with the extent of this controlled through the use of differing liquids such as water, brine, oil, urine or blood (Henderson 2000a, 233). Water that has been used previously apparently gives a more uniform result and may have been conserved in some workshops (Pleiner 2006, 68). Subsequent tempering decreases the brittleness of the material without a drastic decrease in hardness. Tempering involves heating the quenched steel to a relatively low temperature before quenching it again; the temperature reached and the duration of heating controls the changes in the properties of the steel (Craddock 1995, 237-238). Temperature can be judged through colour, a method still used by modern smiths, and a technique which does not work well outdoors due to excess light (Keller and Keller 1996, 137-138; Pleiner 2006, 53).

Current understandings of the physical properties of iron and its alloys, as well as processes such as carburization and quenching, are based on scientific discoveries since the industrial revolution. Early smiths would have had no knowledge of precise temperatures or the concepts of elemental carbon or phosphorous. However, they would have observed their effects on iron and would have explained it in other ways. Iron from different areas, ores or
furnaces which had different carbon or phosphorous contents would have had empirically observable differences in their physical properties. Explanations for these would have varied, but archaeological evidence for the production of composite artefacts from different types of iron (e.g. Tylecote 1981; Ehrenreich 1985; McDonnell 1989; Godfrey et al. 2003; Blakelock and McDonnell 2007) shows that experienced smiths made use of these properties. A good illustration of a non-scientific explanation for changes in the properties of iron can be seen in the story of Wayland Smith feeding iron filings to domestic fowl to create superior iron (Willen et al. 1976). This seemingly apocryphal story may have some basis in actual practice, and the technique may have resulted in the creation of harder iron through a process of nitriding when the manure was burnt to retrieve the iron filings (Martin and Foley 1979; Tylecote 1986, 192).

The processes of primary and secondary smithing can result in very significant losses of the original iron yield from the furnace (Henderson 2000a, 232). The iron is lost through oxidation when being worked and heated in the smithing hearth, and ends up as waste in the form of slag or hammerscale (small flakes of iron oxides which form on the surface of the metal when heated; discussed in detail below). Crew’s (1991) experiments with blooms from a non-tapping furnace showed significant losses of iron in all stages; the combined losses when smithing from bloom to billet, billet to bar and bar to currency bar in one experiment were 70% of the original iron yield. Sim (1998) achieved more efficient results using blooms from slag-tapping furnaces by working smaller pieces of broken bloom and using a form of enclosed tongs which prevented fragmentation (Fig. 2.8). However, he still reported significant losses; historical accounts of bloom smithing in southern India suggest these losses were part and parcel of the primary smithing of blooms (Craddock 1995, 248).

**Smithing Sites**

Smithing could be carried out virtually anywhere and it is not always easily identifiable archaeologically. The best evidence comes in the form of the various diagnostic smithing products which may be found (see below), along with a number of types of features and materials which can also be clues to smithing activity. Smithing hearths are the most obvious of these, but other features that may survive in some form are fuel dumps, waste pits, water troughs and workshops or shelters (cf. Pleiner 2006, 123-134). Shelter is not always necessary when smithing, but where smithing is being carried out over any significant period of time, some form of cover would have been required for protection from the elements and limiting the amount of light (McDonnell 2001). Materials such as charcoal and clay might indicate smithing but they can also be used in smelting as well as other metallurgical, industrial and
domestic activities. Finds of scrap iron, blooms, billet and iron artefacts, particularly tools, can also strongly suggest smithing activities, especially if found together (Pleiner 2006, 122). There is also the potential that smelting evidence could be found, particularly at primary smithing sites.

A hearth with a controlled air supply provided by a bellows, capable of producing temperatures between 700°C and 1200°C, is a necessity when forging iron (Pleiner 2006, 123). In theory, both primary and secondary smithing could be achieved by heating the iron using a simple charcoal pile blown by a bellows (Pleiner 2000, 216). However, in practice it is far more efficient to have some form of insulation which can allow a high temperature to be achieved with less fuel and in a quicker time (e.g. Crew 1991, 29). Tylecote (1981, 42) argues that the most important design element of a hearth is how it protects the bellows. Protection could be achieved through the use of tuyeres of various designs (see discussion above), which could be separate or part of the furnace design. It is not clear if hearths for primary and for secondary smithing were one and the same, or were separate and typologically distinct. The picture is complicated by evidence for some smelting furnaces being reused as smithing hearths (Crew 1991, 29; Pleiner 2000, 226-227), and the archaeological similarities of smithing hearths with domestic hearths (McDonnell 2001).

The majority of smithing hearths identified archaeologically take the form of pits of various shapes (Pleiner 2000, 123-131; 2006, 217-227). The shape may relate to the type of work being performed as well as the size of the artefacts being forged. The pits could be lined with a refractory material such as clay or stone, and in some cases would have had some form of superstructure made of clay, stone, brick or even turf (Pleiner 2006, 123). Other hearths, certainly by the Roman period, were constructed on raised platforms (Thålin-Bergman 1979, 105-106; Tylecote 1981, 42; 1986, 163; McDonnell 1987b), and these have left very little trace in the archaeological record (McDonnell 2001, 499). Generally, identification of a smithing hearth relies on rigorous associations with slag and hammerscale; the identification of a few grams of slag and evidence of some burning is not sufficient as small quantities of slag can move around sites very easily (McDonnell 2001, 502).

**Smithing Products**

The process of smithing leaves a number of products which can survive in the archaeological record; some of these are diagnostic of the process and quite easily identifiable. The most obvious products are finished artefacts; other residues include waste materials such as slag.
and hammerscale as well as – much more rarely – the remains of smithing tools. However, the interpretation of these residues is not always straightforward and smithing slags are less well-understood than their smelting counterparts (McDonnell 1995, 5).

**Slag**

The various diagnostic slags which result from the smelting process have already been discussed, as have the undiagnostic slags which can also be found on smithing sites. The classic diagnostic smithing slag is the smithing hearth cake (termed SHCs here, but also known as plano-convex bottoms, smithing hearth bottoms or slag cakes); this is a plano-convex cake of slag, often with a depression in the upper surface caused by the stream of air from the tuyere (McDonnell 1987b; 1988a; 1991; Crew 1996; Serneels and Perret 2003; Pleiner 2006, 112-120). SHCs form below the tuyere in the smithing hearth and can have quite diverse morphologies depending on a number of factors including the type of smithing taking place, the type of iron being used, temperature and duration of the smithing (cf. Serneels and Perret 2003). SHCs are formed from a combination of materials which vary in proportion depending on the specific smithing operation being undertaken, including oxidised iron from the stock being used, silica from sand used as a flux and from hearth linings, as well as trace elements from the fuel ash (McDonnell 1991). These various materials combine to form a slag very similar in make-up to smelting slag, and larger SHCs can be mistaken for furnace bottoms (Crew 1996) or tapped slag cakes (McDonnell 1987b). In Ireland they have often been interpreted as ‘furnace bottoms’ formed at the bases of bowl furnaces (Scott 1990, 155-158).

The size of SHCs has been used in the past to differentiate them from larger ‘furnace bottoms’ (e.g. Scott 1990, 155-156). It has also been suggested that SHCs from primary smithing may be larger than those from secondary smithing (Crew 1996). However, it is actually very difficult to differentiate between primary and secondary smithing slags, even with detailed analytical work, and contextual evidence needs to be considered (Pleiner 2006, 217). Recent evidence from Irish early medieval smithing sites for very large SHCs relating to bell production (Young 2009d) strongly suggests that SHC size is not a reliable indicator of the type of smithing on a site. However, analysis of large amounts of slag from various sites may allow the identification of particular processes (e.g. bloom refining) on particular sites (cf. Serneels and Perret 2003).

SHCs are not the only slag type which form during smithing and they can actually make up a minority of a smithing site’s assemblage (McDonnell 1991). Amorphous smithing slag or smithing slag lumps are morphologically indistinct slags similar in make up to SHCs. They may result from the clearing out of the hearth while the slag was still fluid, although they may also
be normal products of smithing (Crew 1996). A related slag-type – diagnostic of smithing – recently identified by Young (2009d) is the pro-tuyere tongue. These are very small, irregular tabular slag cakes with a planar upper surface and with stalactitic prills on their lower surface. They appear to have formed underneath the tip of the tuyere in wide hearths (Fig. 2.9) and are sometimes found attached to the tuyere (Young 2009d, 13). An unusual type of smithing residues occasionally referred to in the literature are ‘gromps’: these are fragments of iron and magnetic material (e.g. magnetite) which are cleaned from the unconsolidated bloom or fall from it when it is removed from the furnace; they appear to be diagnostic of primary smithing (cf. Pleiner 2000, 289). Other slag that can be expected from smithing sites include slag prills, fuel ash slags, cinder and fluxed lining slags, all of which are also formed during smelting operations and have been discussed above.

**Hammerscale**

One type of residue is unequivocally diagnostic of smithing: hammerscale (Allen 1986; Unglik 1991; Starley 1995; Sim 1998; Young in Collard et al. 2006; Jouttijärvi 2009). Hammerscale consists of micro-residues formed when molten slag or iron oxide is separated from the iron being worked during primary or secondary smithing. It forms primarily into flakes and spheres, although further typological sub-divisions have been proposed (Allen 1986). Jouttijärvi (2009) details the stages of hammerscale formation and the different types formed at each stage. His system suggests the formation of slag spheres during primary smithing only, and differentiates between scale made up primarily of slag and that formed through oxidation of surface iron. However, his system does not take into account the use of a silica flux during secondary smithing, particularly when welding, during which spherical (or spheroidal) hammerscale is known to be produced (Dungworth and Wilkes 2005). Micro-residues similar to hammerscale can be formed during smelting when slag shells formed around particles of partly reduced ore or bubbles of gas break up, but these will generally be confined to the furnace, unlike true hammerscale (Crew 1995a). Despite some issues, understandings of hammerscale morphology and composition can allow limited interpretation of the types of smithing taking place on an archaeological site (Bayley et al. 2008, 29).

Hammerscale can also be used on a very intimate scale to identify features and spaces not otherwise visible in the archaeological record, such as the location of anvils, pathways and hearths (e.g. Sim 1998; Paynter 2007b; Veldhuijzen and Rehren 2007; Jouttijärvi 2009). Normally hammerscale is found clustered in a rough circle centred forward and to the left of a right-handed smith working at his anvil (Sim 1998, 113). It is also concentrated around the hearth and between the hearth and the forge. Also, flake and spheroidal hammerscale tend to
have different distributions, with spheroidal hammerscale, produced through the violent expulsion of slag from the piece being worked, travelling further from the anvil (Collard et al. 2006, 397). Where large amounts of smithing take place, the hammerscale can be trampled into the ground and become cemented together, forming a ‘smithing floor’ or ‘smithing pan’ (Bayley et al. 2001, 14; Fig. 2.10). Sim’s (1998) experiments suggest that a blacksmith working full time could produce about half a tonne of hammerscale in a year. It is rare to find sites with this level of residue in the archaeological record, and while hammerscale may also have been used as a flux when welding or as an abrasive for polishing, these would not have consumed such large quantities (Sim 1998, 3). Fastidious smiths may have cleaned hammerscale into their hearths where it would be incorporated into macro-slags or they may even have been collected and re-charged into furnaces. However, even where this was the case, the tiny size of hammerscale means that some is always likely to remain in situ around the place of working.

Tools

Ancient smiths required a variety of tools to work iron, many of which would be familiar to a modern blacksmith and most of which are likely to have been made by the smith himself. The types of tools used, such as hammers, chisels, anvils, etc. have been discussed elsewhere (Coghlan 1977, 62-80; Scott 1990, 21-26; Pleiner 2006, 71-108), and issues to do with preservation, identification and interpretation are the focus here. It is important to note that many smithing tools could potentially have been used by a variety of craftspeople. For example, a chisel may have been used by a stone mason or a carpenter as easily as a blacksmith, and hammers have many uses in domestic life as well as in various crafts (Scott 1990, 21). Problems with using tools to identify smithing sites are exacerbated by the rarity of finding tools in workshop contexts; many known early tools have been found in hoards (e.g. Manning 1991c) or as grave goods (cf. Pleiner 2006, 71-75), and finding recognisable blacksmiths tools in any context is rare. This is probably due to a combination of poor survival, difficulties with identification due to corrosion and the value of the tools in antiquity: they were probably very rarely lost.

Smithing tools made from stone are more likely to survive than their iron equivalents. Stone hammers and anvils (Fig. 2.11) are known archaeologically from Britain, Ireland and the European continent (Scott 1983a, 60; Crew 1996) as well as from ethnographic accounts from Africa (e.g. Coghlan 1977, 67; Herbert 1993, 11; Brown 1995, 5-17). Tools made from more perishable materials, such as wooden anvils or anvil bases, twisted withies used as tongs and the range of wooden hafts that would have accompanied iron tools, very rarely survive. Hafting may even have been one role of the smith and it is interesting in this respect that the
tool-hoard from Waltham Abbey in England (Manning 1991c) contained both smithing and woodworking tools, perhaps suggesting that early smiths were proficient in working more than one material.

Tools, Weapons and other Manufactured Objects

The main role of an ironsmith was to make and repair iron objects for use in everyday life, ceremony, exchange, warfare and industry. Smithing products were extremely diverse, and different objects were produced for people at different levels of society (see Goodall 1981 for an overview of smiths' products in the medieval period). It is this diversity and multiplicity of uses which means that iron artefacts are not good indicators of smithing activity on a particular site (with the exception of the tools discussed above). Iron artefacts were highly portable and only began, and occasionally ended, their lives near the smithing hearth. Semi-products such as billets, bar iron or currency bars may be more indicative of smithing, either being produced on site or imported to the site as raw materials. Similarly, scrap iron, i.e. fragments of artefacts which have reached the end of their lives and are to be re-forged into new artefacts, is very suggestive of secondary smithing, although it can be difficult to identify.

Summary

This chapter has discussed the technology of bloomery iron production and working, focusing on the residues and features the technologies leave behind in the archaeological record. The technology can be split broadly into two skill sets: smelting and smithing, with a further subdivision of smithing between primary and secondary, though this does not necessarily mean that different people carried out each stage of the process. The smelting of iron using the direct method is probably the most unfamiliar aspect of early iron technology to modern eyes, used to an image of molten metal worked on an industrial scale. Smithing is a far more familiar process, as many of the techniques used are still used today, though the ways we explain and understand them are probably very different. However, understanding the principles and material culture involved in early iron technology is crucial to piecing together a picture of how iron production fitted into early social systems. This process is made very difficult by problems with preservation, particularly of furnaces, but the robustness of slag and the survival of other features and materials can provide a window through which we can identify the stages of the ironworking process present on a particular site.
Iron technology relies heavily on two key resources: ore for smelting and fuel for both smelting and smithing. The collection and processing of ores and fuels in the past would have required a significant amount of time and energy and may have, as in more recent times, been carried out by specialist workers: colliers and miners. The archaeological evidence for ore collection and fuel production relating to iron technology is fairly limited (cf. Pleiner 2000, 87-105, 115-130; Pleiner 2006, 109-110), particularly in Ireland (Scott 1990, 152-154), though significant new evidence for charcoal production in Ireland has been recovered in the last decade (cf. O’Sullivan and Downey 2009; Kenny 2010). This chapter reviews the different ores and fuel resources available in Ireland, considering their distribution and the methods which may have been employed in their processing for use in ancient ironworking. An understanding of the archaeological imprint of the activities involved in ore and fuel production provides an important foundation for interpretation of Irish ironworking sites in later chapters.

Irish Iron Ores

Unlike metals such as gold, silver, copper and tin, iron almost never occurs in its pure or ‘native’ form, though it can occasionally fall to earth in the form of meteoric iron (Coghlan 1977, 1-7; Craddock 1995, 104-109; Buchwald 2005, 13-29). It is generally found as a chemical compound or mineral associated with other non-ferrous elements and minerals in various forms, from dense rock to placer deposits of sand (Coghlan 1977, 8-17; Serning 1979, 52-61; Tylecote 1986, 124-128; Henderson 2000a, 211; Pleiner 2000, 87-93; Joosten 2004. 10-11). When the iron content of these associated compounds and elements is high enough to enable their use in the smelting of iron they can be called ore. Ore for use in modern iron smelting can have as little as 20-30% iron content but bloomery ore, which produced fayalitic slags containing as much as 50% iron, required much higher iron contents (Craddock 1995, 235; Joosten 2004, 10).

The iron content or ore grade was not the only factor influencing whether an ore was suitable for smelting in a bloomery furnace. The reducibility of the ore, and the chemical composition of the gangue were also very important. Reducibility refers to the capability of the ore to be reduced to a metal. This is a product of the porosity of the ore, as a more porous ore will have
a larger surface area where the reaction process can take place with the reducing agent (carbon monoxide) in the furnace (Joosten 2004, 10). The porosity of an ore could be increased through beneficiation (discussed below; Pleiner 2000, 107).

The final important factor was the composition of the gangue, the non-ferrous materials in the ore. Most iron ores contain silicon dioxide (SiO₂) as the principal gangue material, generally accompanied by other oxides such as aluminium oxide (Al₂O₃), calcium oxide (CaO), magnesium oxide (MgO), manganese oxide (MnO) and phosphorus oxide (P₂O₅) (Joosten 2004, 11). This means most iron ores are self-fluxing, i.e. capable of producing slag without the introduction of a flux (Craddock 1995, 244). Good bloomery ore is not defined by a high iron content, but rather a high iron to gangue ratio, allowing the formation of slag using a minimum amount of iron as a flux (Tylecote 1986, 127). The gangue also includes trace elements which could have important effects on the composition of the slag and iron produced during a smelt. Some elements, such as Ca, Mg and Mn could increase the yield of iron, as they replace the iron in the slag, while others, such as phosphorous (common in many Irish ores; Rynne 2006, 107) and sulphur could change the properties of the iron (Tylecote 1986, 144-146; Tylecote and Gilmour 1986, 7-9; Craddock 1995, 238-239; Charlton 2007, 92-93).

Types

Iron ores can be classified in many ways from their physical properties, formation properties and their mineral content (e.g. Coghlan 1977, 8-17; Tylecote 1986, 124-128; Pleiner 2000, 87-93); they are heterogeneous and a number of criteria are important in assessing their usefulness for smelting iron. The most common division is according to the primary iron mineral in the ore. This allows the distinction of three main groups: oxides, carbonates and sulphides. These scientific classifications are based on a modern understanding of ores, but they do draw on an the ore’s physical properties; traditional miners and smelters likely classified ores based on such physical properties, including colour, weight, density and taste (Craddock 1995, 30-31). Modern surveys of ores and analyses of ancient slag rely on them so a quick introduction is essential (for further discussion of iron ores in Europe see Tylecote 1986, 124-128; Pleiner 2000, 88-93).

Iron oxides (Fe₃O₄) are probably the most important group of ores, and include ore types such as limonite (FeO(OH).nH₂O), haematite (Fe₂O₃) and magnetite (Fe₃O₄). Limonite is not a true mineral but rather a mixture of hydrated iron oxides, primarily goethite (FeO.OH; Tylecote 1986, 125). Scott (1990, 154) notes the occurrence of bedded limonite and haematite in Counties Down and Tyrone in Ireland which have iron contents up to 63% and 70%
respectively. Limonite also occurs as weathered surfaces on ferrous and non-ferrous ore deposits, and many bog and lake ores consist of precipitated iron hydroxides in the form of goethite (see below). Good quality limonite ores contain up to c. 60% Fe (Pleiner 2000, 88). Haematite can contain up to 60-70% Fe and is generally considered an excellent ore, although it can be very dense which can make it difficult to reduce (Pleiner 2000, 88; Joosten 2004, 11). Magnetite can be similarly dense and also has a high iron content (over 70%), which can make it hard to smelt as it is lacking gangue materials to form slag (Pleiner 2000, 89; Joosten 2004, 11).

Iron carbonate ores are common in Britain in the form of sedimentary deposits of siderite (FeCO$_3$) or spathic iron ore, and as clay-ironstone nodules (Tylecote 1986, 124). Siderite can contain up to 50% iron and would generally have been used in roasted form, which would convert it to haematite or magnetite depending on roasting conditions (Pleiner 2000, 89). Reduction of iron from sulphide ores such as pyrites (FeS$_2$) had been thought to be undesirable due to the detrimental impact a high sulphur content would have on the iron, but experimental work has shown that marcasite (FeS$_2$) can be used for smelting after being converted to limonite through roasting (Tylecote and Clough 1983; Pleiner 2000, 108). Sulphide ores can also be used in the form of gossan: intensely weathered or decomposed rock, often the upper cap of an ore outcrop which would be formed by the oxidation of iron sulphides to form limonite (Craddock 1995, 28).

Bog and lake ores are unusual not in their mineralogy but rather in that, unlike geological ores, they replenish themselves (Tylecote 1986, 125). Bog ores are thought to form through the acidic action of peat on underlying bedrock and soils, which results in iron-rich water. Where the water up-wells it can result in the precipitation of the dissolved iron as oxide and carbonate ores (Serning 1979, 57-59; Feehan and O'Donovan 1996, 99-100; Joosten 2004, 11). Lake ores, very common in Sweden, result from the same process, where humic acids extract iron from surrounding soils and rocks, but in the case of lake ores the water up-wells in open water and precipitates as a fine-grained iron oxide which is then converted into the different types of lake ore (Fig 3.1; Serning 1979, 57-58). The iron content of bog and lake ores can vary considerably, and they often have high phosphorous and manganese contents (Tylecote and Clough 1983; Pleiner 2000, 88). Iron pan has also occasionally been identified as a possible ore source, related to bog and lake ores (e.g. O'Kelly 1952, 35-36; Grant 2004, 256-257), but very little is known about the practicalities of using it in bloomery smelting.
Distribution

Iron deposits in Europe are both common and diverse, and a wide variety of sources and types have been exploited since the introduction of iron smelting technology (cf. Pleiner 2000, 87-93). However, the reconstruction of ore distribution in antiquity is problematic, particularly prior to the availability of written sources. Mining is a destructive process, removing the ore being exploited (making subsequent identification difficult), and early works can easily be obliterated by more recent excavations. Also, the smaller ore deposits worked in antiquity may have been worked to exhaustion (leaving no identifiable ore), and may have been located outside the areas of modern surveys which focus on major deposits (Scott 1990, 152; Pleiner 2000, 90). Reconstruction of bog and lake ore deposits is even more problematic due to the loss and destruction of wetlands, a lack of modern surveys and the regenerative properties of the ores (cf. Scott 1990, 153-154).

Ireland has a wide variety of ores spread throughout the country (Fig. 3.2). However, these would not all have been particularly useful or even accessible to early ironworkers. A large proportion of the ore is pyritic (particularly around Counties Wicklow and Galway), and is not likely to have been very useful in bloomery iron smelting if directly mined. However there are likely to have been gossans, weathered ores rich in iron oxides (Craddock 1995, 28; Pleiner 2000, 87), available where these pyritic ores outcropped, though it is not clear if these were used to any great extent in early iron smelting (cf. Tylecote and Clough 1983; Craddock 1995, 234-235). There are also significant clusters of clay-ironstone, a carbonate ore that is a form of siderite and occurs in the Millstone Grit and the Coal Measures in Counties Tipperary, Leitrim, Cork, Derry and Antrim (Jackson 1994). The group that outcrops in Co. Leitrim gave their name to Sliabh an Iarann (Mountain of Iron) and were worked in Elizabethan times (Scott 1990, 154). In the northeast of the island a large area of laterites (remnant basaltic rock formations weathered in a tropical climate) contain iron oxides (Fe₂O₃) with bauxite (an ore of aluminium) in various concentrations and may have been worked where they outcropped (Scott 1990, 154; Rynne 2006, 107).

While our understanding of the distribution of rock iron ores in Ireland is incomplete and based on modern ore classifications, our understanding of the extent and location of bog ore deposits is poorer still (Fig. 3.2). This is primarily due to a lack of surveys, but also the destruction of bogs through drainage and turf cutting, particularly in the twentieth century AD (cf. Scott 1990, 153-154). Bog ore was known historically as a source of iron, though it was called ‘bog mine’ in the sixteenth and seventeenth centuries (Payne 1590; Boate 1652, 70).
Some major bog ore deposits are known to have been worked in the nineteenth century AD for use in the purification of coal gas, with over 200,000 tons of bog ore exported from Donegal alone (Kilroe 1907, 159-160; Feehan and O'Donovan 1996, 100). It is not clear if similar quantities of bog ore were available elsewhere in the country, but where bog existed it is possible, though not certain, that bog ore was available.

The mechanised stripping of bogs in the Republic of Ireland by the semi-state company Bord na Móna, underway since the 1940s, may have destroyed deposits of bog ore, but it has also provided an opportunity for large-scale survey. Fairly large-scale surface survey of midlands bogs by the Irish Archaeological Wetland Unit (IAWU) in the late 1980s and 1990s revealed only two definite bog ore spreads, suggesting it is not a particularly common resource, at least now (Keane 1995, 175-176). A limited survey of freely available aerial photographs of Co. Offaly (from http://maps.osi.ie/publicviewer) resulted in the identification of one substantial bog ore deposit at Derryarkin Bog, Co. Offaly (Fig 3.3). The bog ore shows up as yellow/orange deposits against the black peat revealed by mechanised stripping of the bog. This method may provide an opportunity to expand the number of known sources of bog ore. Another possible avenue for identifying bog ore sources is through place name evidence. Bog or lake ores can colour local water red (cf. Serning 1979, 57-59; Fig. 3.4) and this may be recorded in place names e.g. the Red Bog in County Carlow. This technique has been used previously in Norway to locate potential sites of bog ore (Ole Tveiten 2009 pers. comm.). While our knowledge of bog ore distribution in Ireland is minimal, the sheer extent of bogs, which cover one sixth of the total land area (Aalen et al. 1997, 106), suggests bog ores formed a fairly widespread resource for early iron smelters.

Prospexion

Early metalworkers would have relied on simple but effective methods to locate and identify ores. Vegetation can be used to identify the location of sub-surface ore deposits, with some plants thriving on metal-rich soils (Henderson 2000a, 214). Ores can also be identified through colour, weight, texture and density (Craddock 1995, 30-31). Oxidised iron can have a very distinct colour varying from yellow to brown or red; ochre, a hydrated iron oxide, has been widely used as a pigment for this reason from at least the Upper Palaeolithic (Schmandt-Besserat 1980). Divining, a less scientifically grounded method, may also have been used in the past (Craddock 1995, 31).

It is not entirely clear how bog and lake ore deposits were identified in the past, but a Scandinavian account from the seventeenth century AD describes the probing of bogs to a
specific depth with iron poles with hooks at their ends (Milander 1682 reproduced in Serning 1979, 50-51). When these were pulled up, the soil on the end of them was chewed in the prospectors’ mouths. Sandy soil was not suitable, but if it stuck together like gum it was considered an ore, which was then dug out. Colour may have been an important indicator of ore in Irish bogs. Irish bog ore is light grey in colour prior to exposure and oxidisation, when it can be orange, yellow, brown or red (Kilroe 1907, 160). A survey of Derryrkin Bog, Co. Offaly for this study (Appendix 2) recovered ore which was very distinct, showing as a yellow-orange colour against the black cut-away peat (Fig. 3.5). A shallow section cut through one of the deposits did not reveal any grey ore, but this may have been due to the lowering of water levels through drainage, allowing oxidisation (Fig. 3.6). Tylecote notes that in areas where bog ore contains manganese it can have an indigo colour (Tylecote 1986, 125), suggesting that the colour of bog ore might be locally variable.

Mining

Once identified, iron ores had to be mined. This is unlikely to have been a difficult prospect for early iron smelters, considering the long history of exploitation of non-ferrous ores and the tendency for iron ores to concentrate close to the surface of the earth (Pleiner 2000, 87). Methods of mining vary considerably depending on the type of ore being extracted and their location; they can generally be classified as either surface or sub-surface (cf. Henderson 2000a, 214-219; Pleiner 2000, 93-103). Both methods of mining are known from very early on, with surface mining for mineral raw materials taking place in Ireland in the Neolithic (e.g. Cooney 2004) and the Bronze Age (O’Brien 1994; 1995), and extensive sub-surface mining for copper ores taking place in Wales in the Bronze Age (Dutton and Fasham 1994).

Surface mining can take a number of forms. Ore can form alluvial (riverine) or eluvial (formed by weathering and found in the immediate vicinity of the parent deposit, often at the base of slopes) deposits, which can be worked at the surface and used to trace the location of potentially sub-surface original ore deposits (Craddock 1995 26-27). Near-surface ore could be worked through open-cast methods where the overlying soil is removed and the ore is excavated over a wide area or in pits or trenches (Pleiner 2000, 93-95). Seams which extended to any depth underground would have required sub-surface excavation, which is far more difficult and dangerous and includes problems such as collapse, drainage and ventilation. The excavation of mines may have been carried out with iron tools, once they were available, probably in conjunction with fire-setting. This technique involves setting a fire against a rock face for some hours, thus shattering the rock to a depth of up to 30cm (Craddock 1995, 33). The archaeological visibility of these mines should be reasonably high in the cases where
haematites or bedded laterites were being mined, though clay-ironstone nodules could be collected from river beds leaving no trace (Jackson 1994). The actions of later miners may have destroyed early workings in many cases.

The mining of bog and lake ores is far less likely to have left any archaeological record, largely due to the regenerative nature of the ore but also due to differences in technique. A nineteenth century AD Scandinavian account suggests that lake ore could be ‘fished’ from the bottom of appropriate lakes using a rake which collected the ore into a basket at the bottom of the water. The basket was then raised up to the boat, or in the winter to the ice (Serning 1979, 60). The collection of bog ore would involve digging in water-logged areas and may have required drainage of areas of bog, though small-scale excavation could probably be carried out with little difficulty. Prospection and excavation in the summer when there is less rainfall was probably preferred. One potential indicator of iron ore mining in bogs could be toghers that often lead into bogs; some examples are known which terminate at bog ore deposits (Casparie 1993; though some date to the Bronze Age, perhaps indicating the use of bog ore as a pigment) but very little evidence for this has been found in Ireland despite many years of peatland excavation and survey (McDermott et al. 2009).

Archaeological evidence for iron mining in Ireland prior to the medieval period is practically non-existent, although there are some hints in early medieval literature (see detailed discussion in Scott 1988; 1990, 176-180). None of these can be certainly related to iron mining alone but are nonetheless relevant since mining techniques differ little for different minerals (apart from bog ores, dealt with above). References in the sixth and seventh century AD Irish law tracts note that the presence of a mine increases the value of land and prescribe penalties for the unauthorised removal of ores (Kelly 1988, 105; Scott 1990, 177). One specific passage in the laws titled Bla Miand Midchlaí or ‘The Exemption of Ore is a Mine” may refer to subterranean mining, although the language used is obscure and open to interpretation (Scott 1990, 178-179). Enigmatic finds from a bog close to Clonaslee, Co. Laois of around fifty long-handled dredging shovels embedded in a large deposit of ‘red mine’ or ‘bog ochre’ appear to be good evidence for the collection of what may previously have been lake ore but is now bog ore (Dunne 1869; Frazer 1870). The longest of the shovels was reported to be over five metres long and all of them were found embedded in bog ore at a variety of depths. The ore deposit was very substantial, being between about half a metre and three and a half metres thick and occurring over an area at least 360 metres square. Some of the shovels were found under about two metres of bog ore and another two metres of peat which would have taken roughly
2000 years to form (Conor McDermot 2012 pers. comm.). No other tools related to early iron mining have been found in Ireland.

Beneficiation

Beneficiation refers to the various processes through which ores can be put prior to smelting to enhance iron output. It is a term which applies to a number of chemical, physical or mechanical techniques and refers to the treatment of ores for all metals. Iron was never processed using chemical means, but rather through two primary processes: dressing and roasting (Pleiner 2000, 106-114). The goal of these processes is to increase the grade of the ore, homogenise it and/or change the physical structure of the ore to increase the chances of a successful smelt.

Dressing

Dressing or sorting is often the first stage of beneficiation of an ore. It is the process by which the ore is sorted to remove unwanted gangue and thus increase the ore grade (Henderson 2000a, 220; Pleiner 2000, 106-107). It is generally achieved through mechanical means such as hand-sorting, picking, screening or washing. Crude dressing of an ore would have taken place at the point of extraction when low-grade elements would be identified and discarded. Further sorting could take place at the ore procurement site, at the smelting site or where the ore was washed (sorted into heavy metaliferous components and lighter gangue with the help of water) at a convenient source of water. Archaeologically, there is potential for identifying evidence for dressing, primarily in the form of waste materials and tools. Deposits of low-grade ore may be evidence for sorting, while picking or sorting may leave more ephemeral spreads of ore fragments. The washing of ores is less likely to leave a direct archaeological trace although an early medieval reference to ‘miners washing ore’ suggests it was a method known and used in Early Medieval Ireland (Ó’Corráin 1974, 68; Scott 1990, 177).

Comminution

Comminution of an ore involves the reduction of the grain size through grinding or crushing; the grain size of ores could also be reduced through roasting (Craddock 1995, 156-169). The benefits of crushing or grinding ore may lie in the increased reducibility of the ore but it also allows easier sorting. Comminution would have required stone mortars as well as pestles or hammers made from stone or wood, sometimes metal shod (Craddock 1995, 159). One common artefact on Irish archaeological sites, the bullaun stone, could possibly have served as grinding or crushing hollows for ores (Dolan 2009).
Bullauns are hollow basin-like depressions in uncut stone which can be found throughout Ireland and appear to date to the early medieval period (Dolan 2009). Internationally there is abundant ethnographic evidence for the use of similar stone basins (generally referred to as grinding hollows) in the production of metals. For example, Zimbabwean examples, colloquially referred to as ‘dolly holes’ (Swan 1994; 1996), were used extensively in the first and second millennium AD, in conjunction with related elongated grinding grooves, for the crushing of gold bearing ores into sand-sized particles. They may also have been used for crushing iron or copper ores and possibly for crushing quartz for use as a flux during smelting or as a temper in pottery (Swan 1994, 62). In India large mortars, similar to bullauns, were used to crush silver-lead ores in Rajasthan in the third century BC, while in Karnataka (undated) smaller, shallower depressions were created as a by-product of crushing gold-bearing quartz on flat rock surfaces (Willies et al. 1984; Craddock 1991; 1995, 159-161). In the Bassar region of northern Togo in recent times iron blooms were crushed, often by the smith’s wife, to separate out iron from slag (Philip de Barros 2009 pers. comm.). Ethnoarchaeological work in Sukur, Nigeria (David 1998; David and Kramer 2001, 143-145) has demonstrated the multi-functional use of a variety of grinding hollows including a subset of round, steep sided and fairly small ‘fining hollows’ used by specialist iron producers in living memory to break up iron blooms. Closer to Ireland, Hencken (1933, 276) reported the use of stone basins in Cornwall “in comparatively recent times” for the crushing of tin ores.

It is also possible to point to archaeological and antiquarian evidence internationally for the use of stone basins in the processing of ores. Early reports from Wales identified stone mortars related to copper (Stanley 1869) and gold (Knight 1856) production. At the Riotinto mines in Spain a large number of mortars and pestles from a pre-Roman mining community were used for pulverising the silver ore prior to smelting (Blanco and Luzon 1969; Fendin 2006). Mortars, thought to be used for ore processing and bearing a striking resemblance to bullauns have also been identified at Mugharet al Warda in Jordan, associated with a Byzantine or medieval ironmine (Xander Veldhujen 2009 pers. comm; Dolan 2009). Excavations at The Carrick, Loch Lomond, in western Scotland revealed a bullaun stone associated with metalworking platforms identified by multiple negative features filled with iron slag and charcoal and dated to A.D. 690-900 (David Sneddon 2009 pers. comm.).

It is important to note that in many of the examples given above the mortars were, or may have been, used for smithing activities as well as ore crushing. The evidence from excavated mortars in Ireland reviewed in this study suggests that in general the association with smithing is stronger and many of the mortars should be interpreted as relating to smithing (see Chapter
A large earth-fast rock with two bullaun-type depressions from near Blakeney in Gloucestershire, England, of unknown date, has been firmly connected with iron smithing activities through metallographic examination of residues in one of the hollows (Standing 1977). The residues were identified as smithing slag and slag was found in the area around the stone. The hollows were interpreted as the bases of smithing hearths, but it seems possible that they were mortars or anvils associated with smithing; similar basins were used in the 1940s in northern Nigeria for the shaping of hoes (Fagg 1952) and in eastern Nigeria around the same time for consolidating blooms (David 1998).

Roasting

Roasting, essentially the heating of ores in an open fire, serves a number of functions: it softens the ore, making it more porous and friable, transforms non-oxide ores into oxides and drives off water (Craddock 1995, 167; Pleiner 2000, 107). Comminution may sometimes have taken place after roasting to make the process of breaking up the ore easier (Craddock 1995, 167). Experimental roasting of bog ore for this study (Fig. 3.7) resulted in a very friable and fine ore which did not require any further breaking up. Craddock (1995, 161) suggests that very finely crushed ores would tend to extinguish the furnace fire. Experimental smelting of the roasted Irish bog ore indicates that a very fine ore could be smelted with few issues (Appendix 2).

Roasting is not always necessary, but in the case of carbonate and sulphide ores it is likely to have been very important as it converts them into oxide ores, the most appropriate form for smelting (Maréchal 1985; Pleiner 2000, 107-109). Roasting is a prerequisite for the use of both weathered and un-weathered sulphide ores, although experimental results (Tylecote and Clough 1983) suggest that even this would not remove all of the sulphur, resulting in Fe-FeS eutectic inclusions in the slag. This would mean the iron produced would be viable so long as it was forged below 988°C, at which point the sulphur would enter the metal making it brittle (Tylecote and Clough 1983).

A limited amount of roasting would occur as the ore moves through a furnace. The positive effects of roasting ores suggest it was probably commonly used in the past. Roasting in an open fire would leave little evidence apart from a spread of oxidised ore. Raking after repeated open roasting might leave a shallow negative feature which could be visible archaeologically. Shallow, circular roasting hearths have been identified on a number of early sites in Britain and Continental Europe, and stone-lined horseshoe-shaped roasting pits are known from southeastern England (Pleiner 2000, 110-112). Ditch hearths are known from sites in England,
processing large amounts of ore during the Romano-British period; these are long and rectangular in plan and facilitate the efficient roasting of large amounts of ore at one time (Pleiner 2000, 110-113).

**Potential Fuel Sources**

Fuels and the heat they produce are fundamental to the production of iron. As well as providing thermal energy, they also supply the carbon dioxide/carbon monoxide reducing atmosphere necessary for the formation of a bloom. However fuels were also used at various other stages of iron production including fire-setting when mining mineral ores, roasting the ore, pre-heating the furnace, powering the forge and of course in domestic activities such as cooking and heating which would have paralleled the ironworking activities (Craddock 1995; Pleiner 2000).

**Dung**

Dung – when dried – is used as a fuel in many parts of the world for domestic fires, heating and pottery making. It is a heterogeneous fuel and its properties when burnt depend greatly on the animal that produces it, its diet and the type of husbandry involved. For example sheep pellets, while difficult to collect, can produce a much higher temperature when burned than cow dung, and decisions as to the sheltering of animals, the mixing of dung with other materials (e.g. straw) or its compaction through trampling can have a significant effect on how easy it is to collect, prepare for burning, and on its calorific and combustible properties (Sillar 2000, 48-49).

Dung would have had limited use in the production of iron. It would not be suitable for use directly in the smelting furnace, considering it has a lower heat value (Kcal/Kg) than wood (Winterhalder et al. 1974, Table V). Nevertheless it would have had potential uses as fuel in the firing of tuyeres, the pre-heating of furnaces and general domestic activity around smelting and smithing sites. It is not clear if dung would have been a suitable fuel for the roasting of ores. There is historical evidence for the use of dung as a fuel in Britain as late as the seventeenth century AD (Tylecote 1986, 224) and large quantities of llama dung were used in one sixteenth-century AD Peruvian mine for the smelting of lead ore (Browman 1974, 194). Dung fuel has also been identified archaeologically (e.g. Therkorn et al. 1984; Charles 1998; Vickers et al. 2005), though not in direct association with ironworking.
Peat

The cutting of peat and its drying and storage for domestic fuel is still a familiar sight still in Ireland and it is likely that Ireland’s extensive areas of peat (Fig. 3.8), which have been developing since the start of the Holocene period (Feehan 1997), have been exploited as a fuel since prehistoric times. Peat is generally cut in the early Summer and, when dry, provides a steady-burning reliable fuel source with a calorific value of around 3,300 Kcal/Kg, half that of coal but higher than that of wood (Davis 1911, 58; Feehan and O'Donovan 1996, 21). All peat is not equal and the best quality, dense ‘black turf’ is overlain by more porous brown and white turf (Feehan and O'Donovan 1996, 16). Dried peat could be easily stored and used throughout the year but it would have had limited potential uses in ironworking. It may have been used in the pre-firing of the furnace or in roasting. It could also, as with dung, have been used in domestic activities associated with ironworking. However, peat could also be processed or charred to create peat charcoal with a far higher calorific value that would have been more useful to both smelters and smiths (Mahler and Jouttijärvi 2005; below).

While peat may have been exploited for fuel in Scotland as early as the Neolithic period (Whittle et al. 1986, 88) there is clear evidence for its cutting and stacking in the Bronze Age (Branigan et al. 2002), and Pliny refers to its use in the first century AD in Germany for cooking and heating (Pliny et al. 1964, 153). In Ireland, it is clear that peat cutting was common by the medieval period (Feehan and O'Donovan 1996) and some references in the law tracts suggest earlier use in the sixth/seventh centuries AD (Kelly 1997, 396-397).

Wood

Wood is a familiar material and its usefulness as a fuel is obvious. When felled, wood generally needs to be seasoned to reduce its moisture content. Moisture in wood acts as a heat-sink, requiring energy to vaporise, reducing the burning temperature and making it more difficult to ignite; for this reason kiln-dried wood or ‘white coal’ was used in the past for the smelting of lead (Jones 1993, 49). Bark may have been stripped after felling; in many cases as it retains moisture and in the case of oak, the bark could be used for tanning animal skins. In some later managed woodlands the stripping of bark for tanning prior to production of charcoal from coppiced branches formed part of the management and exploitation of the woodland resource (Carey 2009).

Raw wood is not suitable for smelting due to its oxygen and moisture content (Tylecote 1986, 131). The primary fuel for smelting iron appears to have been charcoal, but historical evidence
from an account of eighteenth century AD bloomery iron production in Scandinavia (Evenstad 1782) has lead to an alternative explanation being put forward by Espelund (1997). Espelund’s contention is that the stacking of wood inside a furnace, and its conversion to charcoal within the furnace would be more efficient both in terms of the conservation of the heat lost in the production of charcoal in charcoal kilns, and the labour expended in the process of making the charcoal. Other uses for wood fuel in the production of iron include its use in roasting ore, in preheating the furnace and as kindling for lighting the furnace. Wood is not suitable for use in reheating of iron as an open fire will not reach sufficiently high temperatures for smithing (McDonnell 2001).

It is not clear how the use of wood in a smelting furnace could be identified archaeologically; wood not consumed during a smelt would survive as charcoal rather than wood. Experimental smelts using wood (Gjerløff and Sørensen 1997; Nørbach 1997b) suggest that appropriate temperatures for reduction can be reached – although over a significantly longer time than when using charcoal – but a substantial bloom has yet to be produced experimentally using wood as a fuel. The question remains open and requires further experimental investigation (Pleiner 2000, 130).

Charcoal

Charcoal consists of wood – or more rarely peat – which has been charred at a high temperature in a low-oxygen environment that prevents total combustion (Pleiner 2000, 115; Figs. 3.9 and 3.10). The process drives off moisture and the various volatile chemical elements of unprocessed wood or peat, leaving a form of carbon (Emrich 1985). The carbon content of wood charcoal can vary between 78% and 92% and it contains varying proportions of oxygen, hydrogen and ash (Pleiner 2000, 115). Due to its high burning temperature, short flame, lack of smoke and easy controllability, charcoal is very suitable for use in a domestic context for heating and cooking (Kenny 2010, 99). It would also have been used in the smelting and working of non-ferrous metals. Charcoal is very important in the smelting process for two reasons. First, it is a very high energy fuel which burns at a high enough temperature to allow formation of a liquid slag in the furnace. Second, the carbon in the charcoal, when combined with oxygen to create carbon monoxide, plays an important role in the reduction of iron ores to iron (see Chapter 2). The archaeological, historical and ethnographic evidence strongly suggest that charcoal was the primary fuel used in both the smelting and smithing of iron in the past (cf. Craddock 1995, 189-193; Pleiner 2000, 115-130).
A wide variety of types of charcoals have been used by ironworkers in the past and the original material used (wood or peat) would have influenced some of the properties/make-up of the charcoal produced. Ethnographic work in Africa shows charcoal from different species of tree could be used for particular processes e.g. smelting or smithing (Thompson and Young 1999). Various charcoal types, made from both hardwoods and softwoods, are known to have been used throughout Europe, varying according to the local wood availability and the technological traditions of smiths and smelters (see Pleiner 2000, 116-118 for a survey of wood varieties used across Europe). Peat charcoal would have been manufactured from dense black peat rather than more porous types (Macadam 1886-87, 95). Charcoal is not a very strong material in comparison to wood or coal and can be crushed easily during transport or when loaded into a very large (e.g. blast) furnace (Percy 1861, 142; Craddock 1995, 189). Peat charcoal experimentally produced for this study (Appendix 2; Fig. 3.9) was particularly fragile, but still perfectly suitable for charging a low-shaft furnace (Mahler and Jouttitjärvi 2005).

It is not clear when charcoal was first produced in a deliberate and controlled manner. Certainly by the Bronze Age it is likely that charcoal was routinely being produced and used in the creation of copper-alloy artefacts and its importance likely increased in the Iron Age (Kelley 1996; Kenny 2010). Pleiner (2000, 119) discusses historical texts by Theophrastus and Biringuccio which describe the production of wood charcoal in the third/fourth centuries BC and the sixteenth century AD respectively. In Ireland, extensive archaeological evidence for wood charcoal production sites has recently been excavated with dates that may stretch back as far as the Bronze Age (Kenny 2010) and as late as the eighteenth century AD (O'Sullivan and Downey 2009). Peat is known historically to have been used for smithing in the Faeroe Islands (Denmark) in the eighteenth century AD, and experimental studies suggest it may also have been used there in the Viking period (Mahler and Jouttitjärvi 2005, 93). Accounts also exist of peat charcoal use in smithing in Scotland in the nineteenth and twentieth centuries AD (Ross 1885-6, 409; Macadam 1886-87, 94-95; Crawford 1966). In rural Ireland it was widely used in the smithing of iron prior to the availability of cheap coal through the rail network in the 19th Century (Evans 1948, 63; Feehan and O'Donovan 1996, 95-96).

Production

The production of charcoal is considered here, as it is an activity which is closely connected to iron production and may have taken place in tandem with smelting or smithing. Traditional wood charcoal production survived in Europe as late as the twentieth century AD, generally practised by specialist workers known as colliers (Armstrong 1978; Aaron 1980; Carey 2009). Charcoal production is a process of controlled burning over a long period of time. The main
requirement is to heat the wood or peat sufficiently that an exothermic reaction begins which drives off unwanted elements, leaving the desired, high calorie carbon (Emrich 1985). In traditional production processes, the heat needed to kick-start the exothermic reaction is generated from the fuel itself. The process is very well understood in wood and is presumably very similar in peat. Yields for wood charcoal produced in traditional pit kilns rarely exceed 15% by weight and are never more than 20% (Emrich 1985, 21) and yields of 20%-30% by weight are all that can be returned from dried peat (Leavitt 1867, 31). There are two main traditional methods of manufacture: the pit kiln and the mound kiln, and there can be variation within these categories (Armstrong 1978; Aaron 1980; ILO 1985; Kelley 1996; Kenny 2010).

The first stage of charcoal manufacture is the collection and preparation (cutting and drying) of the raw material. Peat is cut in the spring and requires about a month to dry in optimal weather conditions (Feehan and O'Donovan 1996, 20). In the pit method (Fig. 3.10), a rectangular or circular pit is dug, varying in size depending on the amount of charcoal to be made. If stacking with wood, care has to be taken that the fire can spread adequately, generally through the provision of vents and air inlets (Kenny 2010, 102); this does not seem to have been an issue with peat (Crawford 1966, 111). After being lit, the pit would have been sealed and covered with green vegetation, soil or sods, or a combination of these (Armstrong 1978, 58; Kenny 2010, 102). Pits for peat charcoal production in the 19th century were long and narrow with one end uncovered (Macadam 1886-87; Crawford 1966), though an unusual circular pit covered by a circular stone with a hole ‘very much like the upper stone of a quern’ was in use on the island of Jura in Scotland in the nineteenth century AD (Ross 1885-6, 409).

Mound, stack or pile kilns appear to have been used only in the making of wood charcoal (Fig. 3.11). An area of ground is cleared, sometimes including the top sods (which could be used later to cover the mound) and the wood stacked in either a rectangular or circular mound (Armstrong 1978; Pleiner 2000, 118-120; Kenny 2010). The mound can be fired through a central chimney, from the sides, or a fire can be lit prior to stacking; it would then be sealed in a similar way to the pit. Burning can take a number of days – depending on the amount of wood/peat – and requires constant attention to ensure the mound or pit does not burn uncontrollably and is not extinguished (Armstrong 1978; Emrich 1985).

Charcoal pits are relatively easy to identify archaeologically. They take the form of pits of various shapes and sizes with evidence of intense burning and, in the clearest examples, a layer of pure charcoal, usually of a single species, at the base (O'Sullivan and Downey 2009;
Mounds are far more difficult to identify, potentially only manifesting as charcoal spreads and areas of burnt soil. A hybrid kiln type, called ‘sunken charcoal piles’ (Pleiner 2000, 122), which incorporated a sunken element with a mound above would be indistinguishable in the archaeological record from pit kilns. Difficulties could arise where kilns were thoroughly or even partially cleaned out. A pit with evidence for extensive burning and limited amounts of charcoal in its fill may not necessarily have been associated with charcoal production. Nevertheless, contextual information, particularly where a pit or spread occurs on an ironworking site may help with interpretation.

Coal and Coke

Coal is a sedimentary rock ultimately formed from ancient peat over extremely long periods and occurring in a variety of forms with increasing carbon contents from lignite or jet (a compact form of lignite) to bituminous coal to anthracite (Reichard 2011, 404-405). Coal was available in Ireland and was mined in recent times, although not throughout the country and not always on the surface (Rynne 2006, 82-97). It can have a carbon content ranging from c. 60% (lignite) to over 90% (anthracite). It is very high in sulphur but this can be reduced through ‘coking’ or roasting the coal in an oxygen free environment to produce coke (Tylecote 1986, 225-226; Craddock 1995, 196-198).

The sulphur in coal makes it very unsuitable for smelting iron, as iron with high sulphur content is very brittle, though this is less of a problem in smithing (Tylecote 1986, 225). Coal was certainly known from very early on, and throughout the early medieval period in Ireland people were using its low-carbon form, lignite, to manufacture ornamental objects (e.g. Gaskell-Brown and Harper 1984; Crothers 1999). There is some evidence for its early use in relation to iron though this is limited to smithing. Theophrastus, writing his treatise On Stones (2.16) in the third or fourth century BC mentions the burning of coals by metalworkers in Greece (Caley and Richards 1956, 48), and there is archaeological evidence for the use of coal in early Roman-British and Roman Iron Age contexts on the continent and in Britain (Webster 1955; Tylecote 1986, 225-226; Pleiner 2000, 129; Craddock and Lang 2005, 42-43).

Summary

Irish iron ores are diverse and widespread but very little is actually known about which sources were used in antiquity or how they were gathered, processed and transported. In contrast there is better evidence for the preparation of wood charcoal in the Irish archaeological
record, though much of it dates after the tenth century AD (cf. Kenny 2010), post-dating the ironworking examined in this study. The labour and time involved in the gathering of ore and the production of charcoal would have been a significant element of the process of iron production. These activities were elements in a wider technology of iron production including smelting and smithing (introduced in Chapter 2) which would have been spread across the landscape. They need not have been carried out by the same people and each would have required distinct sets of knowledge and skills. The archaeological evidence for the organisation of these activities in the Irish landscape during the study period is considered in detail in Chapters 5 and 6.
4. **Assessing the Data: Current Evidence for Ironworking in Ireland**

The Celtic Tiger boom in archaeological excavations in Ireland has been transformative in terms of our knowledge of early iron. Literally hundreds of sites, including many types previously unknown or undefined have been uncovered. The collection and analysis of this new data, using an electronic database, was thus central to this PhD. Information has been collected from diverse sources, both published and unpublished, and the design of the database aimed to capture data which could be relevant to the project’s research aims. The diversity of the evidence combined with the choices made during the design of the database has introduced biases within the dataset. This chapter examines these choices as well as the nature and quality of the data, providing a detailed understanding of its strengths and weaknesses prior to its interpretation in subsequent chapters.

**The Database Design**

The database was designed using Microsoft Access 2007 so that it could be easily linked with a Geographical Information System (GIS) developed using ArcGIS 9.2. The initial design attempted to capture data relevant to both specific ironworking remains as well as evidence for other activities, general site morphologies, features and finds, following recent designs created for similar synthetic projects (Becker et al. 2008; O’Sullivan and Harney 2008a). These databases were chronologically focused, recording general summaries of individual sites. The focus of this study on a specific activity, ironworking, required the addition of a large number of fields recording very specific information about relevant features and finds.

The structure of the project database is based around a large ‘Master Table’ which records general information about each ‘site’ (Fig. 4.1). For the purposes of the project database, a ‘site’ relates to a defined geographic area, usually recorded at one time and by one (group of) investigator(s). The ‘sites’ recorded in the database do not necessarily equate to single or even continuous episodes of ironworking in the past; usually it is difficult to tell whether assemblages result from sustained or sporadic activity. In locations with large numbers of
separate excavations or sites, but with chronologically separate, unrelated periods of ironworking activity, one geographic area is sometimes represented by multiple entries in the database. This allowed the separate recording of sites that could have very different activities being carried out on them, as well as avoiding over-complication of the database structure. The individual fields recorded in the Master Table (cf. Table 4.1) are discussed below; some of these were linked to look-up tables designed to ensure accurate data entry for particular database fields. Sub-tables were created to record, in detail, specific information types for each ‘site’ including dating information and ironworking features (e.g. smelting furnaces and smithing hearths).

A selection of the extensive information gathered in the Master Table, Features Table and Chronology Table are presented in three gazetteers in Volume 2 (Appendix 5). Practical considerations mean that all fields could not be produced in printed form, though the key information has been included for consultation. More detailed information is available through an electronic version of the database appended on CD. Information from the database is also presented through a variety of tables and figures presented in Volume 2 and referred to throughout the text.

The Master Table

The table follows standard formatting following the database program, and the fields are described in this section (below). The only deviation occurred in cases where non-descriptive or non-numerical information (e.g. presence/absence data) was not definitive. In these cases, where ‘yes/no’ fields were used elsewhere, text fields linked to a ‘four-option’ look-up table were created (termed four-option fields from this point on), which allowed for more subtle choices: yes, no, possible and unknown.

Metadata

The first group of fields record metadata about each site, i.e. information about the site itself and the work carried out on it rather than archaeological information (Table 4.1). Each site in the study was assigned a numerical identifier with the prefix ‘IID’, standing for the ‘Irish Iron Database’ (e.g. IID:001). Where one geographic site was given multiple entries, each entry was assigned a unique number (cf. Table 1.1). Where applicable, the Sites and Monuments Record (SMR) identifier, relating to official records of sites and monuments in the Republic of Ireland and Northern Ireland, was recorded. Each site was also assigned a National Grid Reference (NGR) six-digit Easting and Northing which was used in combination with the project GIS to create distribution maps. The co-ordinates, where possible, refer to a rough centre point on
the site. They are generally accurate to the nearest ten metres but some co-ordinates may only be accurate to the nearest hundred metres where limited information was available.

Information about the people and institutions involved in research on each site was included, as was bibliographic information for each site entry, facilitating future work on the dataset. Finally, a number of fields were added to record the quality of information available for each site. These fields record the availability of published sources (in journals, books etc), specialist reports and/or excavation/archive reports. They represent a crude but useful measure of the quality of the data available for each site in the study and are discussed in detail below.

Site Description

A key part of the methodology for the project was the identification of patterns of variability in terms of what types of sites saw ironworking, in its various stages. Each site has been briefly described in general terms, in a memo field called Site Notes, while the ironworking evidence from each site is summed up in the Site Interpretation memo field. These fields are not easily queried and so a shorter text field (Site Type) was created to provide general classifications for each site.

The Site Type field attempts to classify sites according to ‘types’ well-known or accepted in Irish archaeology (Table 4.2; Following Edwards 1990; Mytum 1992; Cooney and Grogan 1994; Raftery 1994; Edwards 2005; 2007; O'Sullivan and Harney 2008b; O'Sullivan et al. 2010a; Waddell 2010), comparable to the ‘Classification’ field in the database of the Republic of Ireland’s National Monuments Database\(^2\) and the ‘Type’ field in the Northern Ireland Sites and Monuments Record\(^3\). While ‘site types’ serve as useful shorthand there is a lack of explicit discussion of such classifications within Irish archaeology; the classifications used by government bodies are historical products that have been modified and added to organically (Avery and Rose 1993; O'Sullivan and Harney 2008a, 6). The various published inventories and surveys (e.g. Byrne et al. 2009; Neill 2009) provide some discussion of particular site types, but they are primarily concerned with classifying unexcavated field monuments and are generally conservative in nature, not taking into account recent re-appraisals of traditional site types such as the ringfort (e.g. FitzPatrick 2009; Kinsella 2010) or the addition of potentially new types such as the recently proposed cemetery settlements or settlement/cemeteries (cf.

\(^{2}\)http://www.archaeology.ie/smrmapviewer/mapviewer.aspx

\(^{3}\)http://apps.ehsni.gov.uk/ambit/Default.aspx
It is important to note the ambiguity of some of the site types used. There is much overlap and inevitable problems with definition, so that for example, many ecclesiastical sites are also enclosed settlements and many sites defined as enclosed settlements may have been associated with the church (e.g. tenants) or even been church or monastic sites. Site Types are also static labels and it is difficult to capture the evolution and change that many sites undergo, though types such as ‘settlement complex’ and ‘ironworking site’ are attempts to sideline this issue to some extent. The final ‘types’ used are defined fully in Table 4.2; they are not objective terms but the use of well known, if sometimes problematic, types makes comparisons easier, so long as some caution is exercised.

More detailed contextual information about ironworking areas on each site is captured in the Associated Features and Location memo fields. The first records detailed information on structures and features associated with ironworking areas on sites and the second describes the location (or locations) where ironworking evidence was found on a site. The memo fields were complemented by fields recording the context of the ironworking including various features such as pits and post-holes and the presence of associated non-ironworking features and finds.

**Chronology**

In order to allow chronological comparison each site in the database is associated with a series of yes/no fields (Table 4.1) relating to specific time periods. The Iron Age was split into three phases, the Early Iron Age (EIA; c. 700 BC – c. 400 BC), Developed Iron Age (DIA; c.400 BC – c. 0 AD) and Late Iron Age (LIA; c. 0 AD – c. 400 AD), and the early medieval period was split into two phases, early medieval A (EMEDA; c. 400 AD – c. 650 AD) and early medieval B (EMEDB; c. 650 AD – c. 900 AD). The Iron Age period divisions follow Becker *et al.* (2008, 16-17), with the Early Iron Age period coinciding with the so-called ‘Hallstatt’ radiocarbon plateau and the later division around the birth of Christ being “... completely artificial ... if however somewhat informed by the knowledge of broad cultural changes elsewhere” (Becker *et al.* 2008, 17). The Early Medieval period, as well as being shortened from its traditional scope for the reasons outlined above (Chapter 1), is also artificially divided, this time into two equal periods of 250 years. While the division is arbitrary, it does relate broadly to a period around the seventh century AD when the beginning of the construction of uni- and multi-vallate enclosures (cf. Stout 1997; Kerr 2007, 86-100; O’Sullivan and Harney 2008b, 59-61; O’Sullivan *et al.* 2010a,
changes in imported and domestic pottery (Campbell 2007a; Armit 2008; Doyle 2009), and the abandonment of ancestral or familial burial places (O’Brien 2009a) may indicate genuine and significant cultural changes.

The period divisions outlined differ from Scott’s (1990, 6-9) chronological framework. He chose, after consideration of the poor chronological structure then available for the first millennia B.C and A.D. in Ireland, to pursue a “ferrocentric” approach (Scott 1990, 8). This split the period between the 7th century BC and the 12th century AD into four Iron Age phases, renaming the conventional Iron Age as the ‘Earlier Iron Age’ and the traditional Early Medieval/Early Historic/Early Christian period as the ‘Later Iron Age’ with both of these split into two phases: A and B. His study encompassed ironworking from the first three of these phases: Earlier Iron Age A, dated c. 7th-3rd centuries BC, Earlier Iron Age B, dated c. 3rd century BC to 5th century AD and Later Iron Age A, dated c. 6th-10th centuries AD. The Scott Chronology text field records the date of sites in Scott’s (1990) corpus according to his chronological scheme.

Scott’s (1990) framework was broadly evolutionary with a transition phase, an establishment phase, and a phase when iron became a commonplace material. While the same overall span was adopted for this study, it was not divided in the same way for a number of reasons. Firstly, the very broad divisions, which suited the poor chronological data available to Scott, would not allow the more fine-grained analysis of chronological change undertaken in this study (see chapters below). Also, the framework is very different from traditional chronological schemes in use in Irish archaeology, making comparison with other studies difficult. Finally, the framework was created around theoretical phases of technological evolution and advancement which were necessarily simplistic but are not supported by the data collected for this study; for example, current evidence suggests a peak in smelting activity in the Developed Iron Age before a drop in the Late Iron Age (see Chapter 7) and not a progressive rise in iron production as suggested by Scott’s (1990, 6-9) model.

It is not suggested that the period subdivisions used for this study necessarily relate to actual cultural or technological changes, though in some cases, such as the beginning of the Iron Age, they clearly do. Instead they are a useful tool, which allows easy querying of the data and quick chronological comparisons. Other classifications include the Bronze Age (BA), relating to any sites with dates spanning a period earlier than the EIa, and broad Early Medieval (EMED) and Iron Age (IA) categories for sites only datable to wider time periods. A ‘Late’ category indicates sites with date-spans extending later than the ninth century AD.
Sites were assigned to chronological phases based on the full span of dates relating to ironworking, *i.e.* charcoal or datable artefacts from fills containing slag or from stratigraphically related features. When assessing radiocarbon dates, they were assigned to the period primarily covered by their range at $2\Sigma$; where this covered more than 50 years in another sub-period they were also assigned to that period, unless contrary evidence was available. This means that sites which were in reality short-lived but are not closely dated, or date close to the boundary of two phases, can be assigned to more than one chronological category *e.g.* Late Iron Age and early medieval A. A sub-set of sites could only be dated broadly to the Iron Age or early medieval period. Many broadly dated early medieval sites could also date later than the tenth century and so were also included in the ‘Late’ category.

A field called *Chronology Notes* was used to give a brief summary of the dating evidence for each site with the broad period of the ironworking (*e.g.* Iron Age, Early Medieval, Iron Age/Early Medieval, Early Medieval/Late) on the site being indicated in a text field called *Broad Chronology*. A field called *Scientific Date* indicates the availability of a radiocarbon or dendrochronological date related to ironworking on the site; any known details of such dates were recorded in the Chronology Sub-Table (see below). Finally, the *Date Quality* field grades the reliability of dating evidence from the site (also discussed below). Dating evidence for individual sites is discussed in chapters below, and presented in both the Sites and Chronology Gazeteers (Appendix 5).

**Finds**

The recording of all finds from sites was not a primary aim of the study. However, an attempt was made to record the presence, and sometimes the number, of artefacts potentially related to iron production. It was hypothesised during the design phase that both bullaun stones and grinding stones (a broad category including grindstones, honestones and whetstones), both of which are potentially related to iron production (*cf.* O’Connor 1991; Dolan 2009), might be useful indicators of ironworking on sites. An attempt was also made to record tools potentially used in iron production such as hammers and tongs. This was done using four fields (*Metalworking Tools, Hammer, Tongs*, and *Other*) and a memo field to record any other pertinent information.

**Other Industrial Evidence**

This group of fields was intended to capture information about other ‘industrial’ activities besides ironworking. In this context, ‘industrial’ refers to non-agricultural activities such as
non-ferrous metallurgy, glass, stone and bone working (Other Metallurgy, Other Industrial), and evidence for tuyeres or other types of bellows protectors which might be associated with any pyrotechnical industry (Tuyere/Bellows Protector). Notes for all of the fields in this group were recorded in a memo field (Details).

**Ironworking Remains**

The primary goal of the database was to record the character of ironworking on each site. This meant not just simply recording the remains but also, where possible, identifying the particular processes represented on site. Slag is by far the most common indicator of ironworking on sites and its presence was recorded using a four-option field as well as a numerical field to record the quantity and a memo field to record details about its character. An attempt was also made to record the presence of ‘furnace bottoms’, where they were recorded, and their quantity. It is possible that many reported ‘furnace bottoms’ are actually Smithing Hearth Bottoms (SHCs) and therefore indicative of smithing (see discussion in Chapter 2). However, the term is used very loosely in the literature and reported furnace bottoms were not interpreted as evidence of smithing without other corroborating evidence. Two fields (Lining and Flux) were added to make the information recorded in the memo field Slag Notes searchable. These fields indicate sites with reported evidence for substantial remains of furnace/hearth lining or superstructure, or evidence of potential flux materials such as shell or bone being used.

The presence of ironworking hearths and furnaces is recorded in the fields Hearth and Furnace, with summary details in the field Furnace/Hearth Notes. Far more detailed information for individual hearths and furnaces is recorded in the Features Table (see below). Two fields (Smithing and Smelting) record evidence for smithing and/or smelting on each site, based on published reports and unpublished archive and specialist reports. Evidence for smithing is clarified further through fields recording hammerscale, the presence of an anvil or smithing floor and whether primary or secondary smithing was identified on the site. Further detail is recorded in the fields Smithing Notes and Smelting Notes and in fields recording the presence of ore, bloom(s) and evidence for roasting.

**Fuel**

Three fields recording evidence for fuel production and use are included in the Master Table: the presence of evidence for charcoal production on a site, evidence in any form for the use of peat or peat charcoal, and relevant details including charcoal identifications of fuel used in the ironworking on a site (Fuel Notes).
The Features Table

The Features Table records detailed data on individual furnaces and hearths to facilitate their re-assessment (see Table 4.3 for a list of all fields in the table). Individual features were examined in detail and re-interpreted based on drawings and photographs in published and archive reports, as well as from context descriptions and slag descriptions in specialist reports. During data collection it became clear that some recently-excavated sites had very rich remains, particularly of smelting furnaces, and that it might be productive to record further details such as the context, location and design elements of individual features. These attributes had been generally recorded in the memo fields, but a number of extra fields were subsequently added to make them searchable and quantifiable.

The table does not record all features identified as ‘hearth’ and ‘furnace’ in the literature, as author’s identifications were often based on limited or out-dated knowledge or evidence. Instead, only those features interpreted as definite or very probable ironworking features, based on the review of current understandings of iron technology outlined in Chapters 2 and 3, were included. This was based on an assessment of the morphology of the feature, evidence for burning, lining, slag reported from features, as well as the opinions of the specialists and excavators (although these were not always accepted).

Metadata

Each feature was linked to the IID of the site on which it was found as well as being given a unique Feature ID. Where the features had been assigned numbers or other identifiers in reports or articles this was recorded in the Notes memo field. Dates from features were not recorded in this table; instead, all dates were recorded in the Chronology Table and this was linked to the Features Table through the Feature ID field (see below).

Morphology

The morphology of each feature is described in a field (Notes) that was also used to record other relevant information. Reported dimensions were recorded using three numerical fields: Length, Width and Depth. However, the dimensions of features were not consistently reported. Many furnaces had ‘halos’ of heat-affected soil surrounding them; in some cases the dimensions given related to the size of the halo rather than the original cut. For this reason, where available, plans, section drawings and photographs were examined and an estimated Maximum Internal Diameter (MID) was recorded for individual features. This measurement takes into account any lining material, and gives a more accurate measurement of the original internal diameter of furnaces.
The general shapes of features are recorded using the fields **Plan**, **Side** and **Base**. These record the profile of the feature as well as the plan in a basic but searchable manner. Plans were differentiated according to whether they were circular, oval/sub-circular, rectangular, figure-of-eight, irregular or indeterminate. Features that were figure-of-eight in plan were sometimes interpreted as two separate furnaces/hearths, and in these cases they are recorded separately in the Features Table with both being identified as figure-of-eight. The sides of features were classified as being concave, sloping, steep, overhanging, irregular or indeterminate. This **Side** field refers to the sides of the furnace or hearth pit and not to the superstructure. The base of each feature was classified as being concave, flat, irregular or indeterminate. Further detailed information about methods of construction and design was captured through the fields **Lining**, **Superstructure**, **Arch/Opening**, **Stake/Post**, **Holes**, **Flue/Pit** and **Blowhole**. Furnace and hearth morphologies were recorded in detail in order to provide a general idea of the characteristics of Irish ironworking features (discussed in Chapters 5 and 6).

**Location**

This group of fields was designed to characterise furnaces according to some of the features around them. The field **Sunken** records if a feature is located within a sunken area. These sunken areas include deliberately excavated areas as well as the positioning of features within excavated or partially silted ditches. Where a feature was cut into a ditch, silted-up or otherwise, this is recorded in the **In Ditch** field. Finally the **Context** field records whether a feature occurred on its own, in a pair or in a group. This refers to features in the immediate vicinity and not to features throughout the site; for example a site may have multiple furnaces in various locations all recorded as ‘single’ furnaces.

**Fill**

A **Description** field records in detail the fill(s) of each furnace; the available information varied significantly in detail across the various features. Any dates or slag analysis particular to the feature are also recorded in this field. **Slag In Situ** records the existence of slag in the feature that is interpreted as being left in place from an episode of smithing or smelting. The **Slag Weight** field records the weight of slag in a feature, regardless of whether it was re-deposited or in situ. The presence of tap slag or potential tap slag is also recorded.

**Interpretation**

The final group of fields classify features according to their use in either smithing or smelting, or occasionally both. This is done using the fields **Furnace** and **Hearth**. Another two fields
capture features that were likely used in ironworking, but where the particular use is not clear, and where an ironworking hearth or furnace has also been used in non-ferrous metallurgy.

The Chronology Table

The Chronology Table (Table 4.4) includes scientific dates, particularly radiocarbon dates, calibrated to 95.4% probability using OxCal v4.1.7 (Bronk Ramsey 2009) unless otherwise stated, as well as a small number of dendro dates. The dating information recorded in the table is complimentary to that recorded in the Master Table. Only selected dates that related either directly or stratigraphically to ironworking features/deposits were recorded. The Database ID field links each date to a site in the database while the Feature ID links dates that relate to particular furnaces or hearths to the appropriate feature in the Features Table. The remaining fields capture the standard information required for calibrating, interpreting and assessing the dates (following Chapple 2010b) including Laboratory number, BP Date, standard deviation and material dated. Bibliographic information for the dates is included in the References field in the Master Table and Table 1.1.

Data Collection and Quality

One of the goals of the project was to include and examine all potentially relevant sites within the project database. On this basis, the initial round of data collection was very broadly based, identifying 418 sites with evidence of ironworking potentially dating to the Iron Age or Early Medieval periods which were entered into an early version of the database. It quickly became clear that the large number of potential sites both required and facilitated a rigorous selection process (discussed below) so that only high quality data was included in the final database. Ultimately, 202 sites (Table 1.1) were included in the final database with 228, including sites identified too late for inclusion, excluded (cf. Table 4.5).

Collection

A survey of the online excavations bulletin for the original project proposal identified 54 new ironworking sites excavated between 1990 and 2002 to add to the 106 identified by Scott (1990). This was always seen as a baseline number but the actual number of potentially relevant sites finally identified through this research was 430, far higher than originally anticipated. It is thought that most of the potentially relevant sites excavated up to 2005 are included. These sites were identified on a very broad basis; essentially any site with evidence for bloomery ironworking that could plausibly be dated between the end of the Bronze Age and the end of the (traditionally defined) Early Medieval Period, in the twelfth century AD, was
Evidence for ironworking, in practice, usually meant the presence of ferrous slag on a site. Often the specific type of slag on a site was not reported but in these cases the sites were still included in the initial phase of data collection, with an assumption that they were likely to be ferrous slags, as non-ferrous slag is comparatively rare (cf. O’Brien 2004).

Data has been collected from a variety of sources, both published and unpublished, using Scott’s (1990) comprehensive list of sites excavated prior to the 1990s as a starting point. This comprised 106 sites, although only 66 of these were included in the final database (see Table 4.5 for information on why individual sites were excluded). Three of these (Altanagh, Co. Tyrone, Carraig Aille I & II, Co. Limerick and Lisleagh, Co. Cork) were split into more than one site in this database. Altanagh was split into two sites (Altanagh Phase 1 (IID:004) and Altanagh Phase 2 (IID:005)) as it had two chronologically distinct phases of ironworking. Carraig Aille I &ll was split to become Carraig Aille I (IID:041) and Carraig Aille II (IID:042) as they were spatially, and possibly chronologically distinct, and a closely-related site also reported by Ó’Riordáin (1949a) was added (The Spectacles: IID:184). Two ringforts at Lisleagh were recorded by Scott (1990) as one site but they were included in this study as separate sites: Lisleagh I (IID:141) and Lisleagh II (IID:142) as it is not clear that they were used contemporaneously for ironworking. Of the final corpus of sites, sites already examined by Scott make up only 33%.

The online excavations bulletins up to 2005 were searched for any sites whose descriptions included the terms ‘slag’, ‘furnace’, ‘ore’, ‘smelt’ or ‘smith’. Sites that were clearly post-twelth century AD were excluded; those that fit the chronological criteria were included in the initial database. A search of all the online SMR entries classed as ‘metalworking sites’ produced a very large number of entries which were then filtered: sites with no descriptive details or sites clearly post-dating the study period were excluded. Two recent national surveys of published sites (Becker et al. 2008; O’Sullivan and Harney 2008b), both of which listed known sites with evidence of ironworking, were cross-referenced against the sites already identified.

The sources discussed above identified the vast majority of potential sites but not all. Monographs detailing excavations on major infrastructure projects (e.g. Cleary et al. 1987; Grogan et al. 2007; Carlin et al. 2008a; McQuade et al. 2009) were reviewed, as were periodicals such as Archaeology Ireland and Seanda, which have short turn-around times for

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4http://www.excavations.ie
5http://www.archaeology.ie/smrmapviewer/mapviewer.aspx
publication and thus contain information about recently-identified sites. The National Roads Authority online database\(^6\), launched in August 2008, provided information on new and previously-known sites. It is important to note that the excavation bulletins for 2006 and 2007 (Bennett 2009; 2010) were published in late 2009 and early 2010 respectively. This was too late to allow a comprehensive assessment of the sites summarised in the two volumes. Nonetheless, a number of sites listed in these volumes that had already been identified through other sources were included in the final database. The identification and addition of sites to the database was halted in June 2010.

Following the initial identification of potential sites, a literature review was undertaken to identify all available sources for each site. This was facilitated by the use of online bibliographic search tools such as the Bibliography of British and Irish History (formerly the Royal Historical Society Bibliography), The British and Irish Archaeological Bibliography, The Regesta Imperii Opac, Google, JSTOR and the National Library of Ireland’s Database for Irish Research.\(^7\) Where sites were unpublished or only part-published (i.e. mentioned in a book or journal but not fully published) every effort was made to contact the original excavation director, commercial company, government organisation or other relevant party for further information and in many cases it was possible to obtain copies of preliminary or final archive reports and/or specialist reports prior to publication. These are cited where relevant, and are linked to the sites in Table 1.1.

As has been noted, the number of potential sites identified and entered into the first phase of the database (418) was far in excess of the anticipated number of relevant sites. The data available for many of them is incomplete, fragmentary or insufficient for assessment, and the dating evidence for many was of a low quality or was not necessarily applicable to the slag or other metalworking remains on the site. For these reasons, a second-phase re-assessment of the data was undertaken with stricter chronological parameters being used to focus the dataset, thus securing a more useful, accurate and reliable corpus of information. Sites that did not fit the chronological focus, or that had insufficient data were excluded from the dataset. As was discussed in Chapter 1, the chronological focus of the study lies between the end of the Bronze Age (c. 600 BC) and c. 900 A.D., when it is hypothesised that Scandinavian settlement on the island may have resulted in significant changes in cultural and technological practice in

\(^6\)http://archaeology.nra.ie/

iron production that lie beyond the scope of this study. Evidence from recently excavated sites had also shown that bloomery ironworking may have continued as late as the post-medieval period at Mucklagh, Co. Offaly (Twomey 2008; Young 2008c) and possibly Clonfeacle, Co. Tyrone (Young 2004) and Carrickmines Castle, Co. Dublin (Young 2006g), demonstrating the importance of independent evidence for the antiquity of bloomery slag from a particular site. With this in mind, the sites were re-appraised and only sites with clear ironworking activity thought likely to date prior to the tenth century A.D. were retained.

The final number of sites included in the study (202) represents, in purely numerical terms, a significant increase (194%) in the available data when compared with those available to Scott (1990; Fig. 4.2). The sites included were excavated by a variety of sectors (Fig. 4.3) as were those looked at by Scott (1990; Fig. 4.4). However, while Scott’s sites were predominately excavated (or sometimes surveyed) in the context of research by universities, local societies or independent researchers (54% of the sites on Scott’s (1990) list), the commercial sector was the largest source of sites for the current database, providing 51% of the final site list, compared with 1% in Scott’s assessment. This reflects changes in the character of Irish archaeology in the last two decades and has important implications in terms of the quality and scale of excavations.

Quality

Even following the selection of sites with reasonably good chronological information, the data included in the final database is of varying quality. In this context ‘quality’ can be defined as being a measure of the amount, detail and type of information available as well as the coverage, both chronological and geographic of the dataset.

Publication

Publication status is used as a crude but useful measure of the quality of available information for sites included in the database (Fig. 4.5). A site is considered ‘published’ if no further excavation report or other major work is expected. In general this means a full stratigraphic and interpretive discussion is available with associated plans and sections of the site and its features. There are exceptions to this, in particular older excavations such as at Nendrum, Co. Down (IID:163), where the original excavation report (Lawlor 1925) is not to a modern standard. Published sites represent 46% of entries in the final database with the remainder consisting of sites that are part-published (21%) or unpublished (33%). Part-published sites are those for which some summary information has appeared in print but for which further significant publications are awaited (e.g. Moynagh Lough; IID:158, Lisleagh 1; IID:141).
Unpublished sites include those referred to briefly in print as well as those reported only in the excavations bulletins, the online SMR or the NRA online database.

Some part-published or unpublished sites do have substantial information available in the form of interim or final unpublished reports (Fig. 4.5). These are grey-literature: academic and commercial reports which contain varying amounts of information. Interim reports often include only basic stratigraphic discussion with little chronological information. Final reports commonly contain in-depth discussion of stratigraphy, detailed descriptions of individual features, fills and artefacts as well as specialist reports on scientific dating, slag analysis, finds analysis, environmental analysis etc. It is the availability of detailed final reports for many sites which allows the in-depth re-examination of the archaeology of iron technology given in Chapters 5 and 6.

Overall, 37% of the sites in the final database had specialist analysis of the ironworking remains available (Fig. 4.6). Published sites had the lowest proportion (32%) followed by unpublished (36%), with part-published sites having the highest proportion available (47%). This contrasts with Scott’s (1990) list, with 25% of published sites having specialist analysis, 23% of part-published and no unpublished sites having any analysis available (Fig. 4.7). These figures are a little skewed as the three part-published sites in Scott’s (1990) list with specialist analysis – Knowth, Co. Meath (not included in this study), Lisleagh, Co. Cork (IID:141-142) and Rathgall, Co. Wicklow (IID:171) – have actually only had analysis carried out in the last decade, after the publication of his list (Cherubini 2005; Rehren 2007; Eogan et al. 2010).

The availability of specialist analysis does not indicate consistent quality. Commendably, many sites excavated in the early years of Irish archaeology (e.g. Ballinderry II; IID:012, Lagore; IID:135 or St Gobnet’s House; IID:186) had specialist analysis carried out (Hencken 1942; 1950; O’Kelly 1952), but the sites generally required significant re-interpretation given changes in understandings of iron technology (see Chapter 2). Specialist ironworking analysis was not carried out for all recently excavated sites but the quality of recent reports, particularly on very substantial ironworking sites such as Clonfad, Co. Westmeath (IID:058; Stevens 2009; Young 2009d), Derrinsallagh 4, Co. Laois (IID:077; Wilson 2006; Photos-Jones and Wilson 2007a; Young 2008a; 2008d; Lennon 2009c) and Lowpark, Co. Mayo (IID:151; Anguiliano 2008; Gillespie 2008; Wallace 2008; Gillespie 2010), is very high. At the same time, much specialist analysis has been undertaken in something of a vacuum, with different specialists unaware of each other’s findings or interpretations. Still, the existence of specialist reports, regardless of interpretive differences, is generally an indicator of detailed reporting of features and
metallurgical debris that offers significant opportunities for re-examination and synthesis. Equally, even where specialist analysis is not available, the awareness of and quality of reporting of metallurgical features has improved significantly in the last two decades, even if interpretation often continues to revolve around the concept of the ‘bowl furnace’ (e.g. Photos-Jones 2008a).

**Chronology**

Chronological information was graded according to numerical labels (Fig. 4.8). Category 1 sites have absolute dating evidence directly associated with the ironworking evidence on a site. This includes radiocarbon dates on charcoal from the fills of furnaces, dumps of slag, working surfaces etc. The next category (2) indicates a date that can be confidently associated with ironworking evidence, including direct associations with datable artefacts and stratigraphic associations of ironworking material with other dated layers, for example slag in the basal fill of a ditch with a date available from one of the upper fills. The reliability (i.e. degree of reworking) of stratigraphical associations was assessed on a case by case basis based on information from excavation reports. Categories 3 and 4 require more caution as they indicate less certain dating for the actual ironworking evidence on a site. They both indicate the dating of ironworking evidence through non-direct association with broader site evidence: absolute dates in the case of the former and site morphology in the latter. Sites with ironworking identified from surface or eroded scatters were assigned to Category 5 and those with no dating evidence given the lowest grade (6). One further grade (0) records sites that have been dated by other authorities but where the evidence on which the date is based is not available. This category includes sites where radiocarbon dates are reported but their details are not available.

All sites (418) entered into the database during the initial stage of data collection were given chronological grades and it became clear that many had very poor dating evidence (Fig. 4.8). Only sites graded between 1 and 4, as well as those dated by other authorities (0) were included in the final database. The final corpus of sites has a very high proportion (62%) of well-dated sites graded as either 1 or 2. The number of sites increases over time from the Bronze Age to the Early Medieval period (Fig. 4.9). At first glance this could be read simply (as per Scott 1990) as a reflection of increased acceptance and use of iron technology in society through time. However, an examination of the grading of dates (Fig. 4.10) in different time periods shows that sites dated to the Iron Age rely heavily on direct radiocarbon dating (Grade 1) while those dating to the Early Medieval period are more likely to be dated stratigraphically (Grade 2) or through an indirect date from the site the ironworking evidence was found on.
(Grade 3). Also, sites categorised as ‘Early Medieval/Late’ are likely to be Grade 3 or 4, often relying on broad indirect dates based on site morphology, artefacts or sites with large date ranges (reflected in the category description). These trends may indicate a disproportionate identification of Early Medieval sites due to a relative abundance of datable site morphologies and artefacts from the period. However, considering the difference in relative chronological spans of the Iron Age and Early Medieval periods (1100 years vs 500 years), ironworking sites from the latter period may genuinely be more common, or better preserved.

**Geography**

The geographic spread of sites in the study is reasonably wide, showing, as might be expected, the geographical ubiquity of ironworking in the study period (Fig. 4.11). Nonetheless, there are differences in density which require explanation. A comparison with the distribution of sites identified by Scott (1990) shows a similar spread, though some significant areas of absence have been filled in since (Fig. 4.12). Only three counties, Wexford, Leitrim and Carlow, now have no known ironworking sites and the bias towards sites in Northern Ireland in Scott’s corpus has been corrected. Some counties such as Meath, Cork, Laois and Kilkenny have shown a huge rise in the number of known sites (Fig. 4.13).

The distribution of Scott’s (1990) sites reflected the development of archaeology in Ireland prior to the 1990s. In the south, excavation programmes such as the Harvard Expedition and campaigns by academics funded through the government employment scheme focused on religious sites as well as high-status settlement sites such as ringforts and crannogs (cf. Waddell 2005). The geographic areas investigated depended largely on the research interests of individual academics in the various universities. Excavations in Northern Ireland reflected the significant number of government funded research and rescue excavations, many of which focused on ringforts and raised raths. Newly identified sites in this study follow a different pattern, with if anything a bias against the north of the island (Fig. 4.12). Many of these sites are the result of commercial excavation and as such are focused around major infrastructural projects and centres of construction. Indeed, so much evidence has been uncovered through the various motorway schemes that sites can be seen to radiate away from Dublin along the various arterial routes, particularly the M3, M6 and M7/M8 (Fig. 4.14). Areas that have not seen such major infrastructural transects across the landscape have correspondingly low numbers of sites.

The massive motorway excavations, which sampled large swathes of the landscape, show the ubiquity of ironworking sites, with examples found along almost all routes. One exception
seems to be the M9, which passes through Carlow, a county with no sites included in the study. However, the lack of sites from this road scheme is a product of its recent construction. At least two sites from the scheme: Moyle Big (Hughes 2009) and Cloghristick (Hackett 2009) produced evidence for ironworking and await publication, but were identified too late to be considered in this study (cf. Table 4.5). Wexford has had some excavation connected to the M11 road upgrade but despite this no relevant datable sites have been identified from the county. This may reflect a genuine absence of ironworking activity along the route of the road or possibly a lack of publication of sites from the scheme. It is unlikely to indicate a real lack of ironworking sites in the county during the study period; an absence of iron use in the area over more than a millennium seems impossible considering the situation in the rest of the country. The scarcity of sites in Co. Leitrim is, on the other hand, not surprising considering the lack of major road projects in the county; it is unlikely to relate to past realities.

The distribution of sites in the study is clearly heavily influenced by the various roads projects undertaken throughout the country and this makes comparison on a national level between areas with and without such schemes very problematic. However comparisons between the areas excavated in advance of road schemes is far easier, and far more reliable. In this context the variation in the frequency of sites on different stretches of roads is notable. For example, a particularly large number of sites with ironworking material were uncovered along the M3, as well as along stretches of the M18 and M8, north of Limerick and Cork respectively (Fig. 4.14). The density along the M3 in particular is striking; in other cases it is difficult to tell if gaps are due to a lack of sites or a lack of publication. In the case of the small number of full or part-published road schemes including the M3 (Deevy and Murphy 2009), the M4 Kinnegad-Enfield-Kilcock (Carlin et al. 2008a), the N4 Sligo inner relief road (Danaher 2007), the M8/N8 Cashel to Mitchelstown (McQuade et al. 2009) and the N5 Charlestown bypass (Gillespie and Kerrigan 2010) there is definitely variation, though all apart from the N4 Sligo inner relief road produced evidence for ironworking in one form or another.

Summary

The structure of the project database is not particularly complex but the final design captures a huge amount of information, both general and detailed, about the context and the specifics of ironworking technology in the Irish Iron Age and early medieval periods. This data represents a significant advance in scope and quality when compared with that available to Scott (1990) in his previous study of Irish iron technology. It is thought that the collection process has
identified the vast majority of potentially relevant excavated sites and the final corpus represents a high-quality sub-set of these.

Ultimately the dating of sites, and of ironworking activity within sites, is absolutely crucial to understanding historical processes, social practices and technological decisions and a significant proportion of sites in the final database have high-quality chronological information. Many have absolute dates, often related directly to ironworking activity. A substantial proportion of sites in the study also have comprehensive accounts of their archaeology available in the form of published or unpublished reports which allow detailed comparison and re-assessment.

This increase in both the quality and range of excavated evidence available is largely a product of the boom in archaeological investigation of the last two decades and this is reflected in the geographic spread of sites. Sites in the study are spread throughout the island and a previous bias towards the north of the island has been corrected. Major infrastructure projects have identified ironworking sites in areas of the landscape previously untouched by targeted research excavations and it is now clear that ironworking sites were common across the country.

The data gathered for this study appears to be sufficient to provide a reliable foundation for a theoretical reconstruction of Irish iron technology and to answer the project’s research questions:

- What technologies were used in the smelting and smithing of iron, what signature have they left in the archaeological record and how have they changed through time?
- How was iron production organised in the Iron Age and early medieval periods and what implications does this have for the wider organisation of society?
- What was the scale of iron production in different times and places and what implications does this have in terms of control of production, identity, status and ritual/practical knowledge?
- Who were the producers of iron in the Iron Age and early medieval periods, what role did they play in society and to what extent were they specialists?

The robustness of this data will become clear in the following analysis chapters. Detailed information about the material culture and archaeology of ironworking will allow the re-assessment of the archaeology of smelting and smithing undertaken in Chapters 5 and 6. The
same information, combined with more interpretive data identifying ironworking processes and characterising site types will also enable a theoretical understanding of the organisation, scale and social context of iron technology through time, ideas addressed in Chapters 7 and 8.
5. THE ARCHAEOLOGY OF BLOOMERY IRON

SMELTING IN IRELAND

Smelting, the extraction of metallic iron from its ore, leaves a specific archaeological signature distinguishable from that left by smithing. It was frequently carried out in different locations from smithing and probably sometimes by different people. Despite the best efforts of previous scholars, the archaeology of Irish iron smelting in the Iron Age and early medieval periods has previously been poorly understood, largely due to a lack of good data and an understanding of smelting technology focused on the bowl furnace.

Research for this project has identified 38 definite smelting sites with 88 furnaces spread throughout the country and spanning the entire study period (Fig. 5.1, Table 5.1). This substantial dataset has facilitated the re-assessment and characterisation of the archaeology of early Irish bloomery smelting technology presented below. Smelting sites were defined primarily by the identification of smelting furnaces, though smelting slag and other indicators such as ore and unconsolidated blooms were also considered.

Raw Materials

Raw materials including ore, fuel and clay are a fundamental part of the smelting process and their sourcing, collection and preparation would have represented a significant investment of labour and time. The location and extraction of raw materials is not a primary focus of this study but new evidence from production sites is briefly reviewed here, allowing a better understanding of the types of ores and fuels used in early smelting.

Ore

Direct evidence for ore is very rare on smelting sites in the study. Only seven sites had ore identifications confirmed by a specialist, with a larger number of unconfirmed reports (Table 5.2). Rock limonite, siderite, yellow ochre and bog ores have been identified with some confidence (Collins 1955; Murphy 1961; O’Kelly 1963; Photos-Jones and Wilson 2006a; Photos-Jones and Wilson 2007b), with possible examples of haematite, ironstone and limonite in the
form of both iron pan and bog/lake ore also recorded (Table 5.2). Even when bloomery sites excluded from the study due to poor dating are reviewed, the evidence for ore use remains very limited (Table 5.3). There are no clear instances of mining of iron ore or of smelting in the vicinity of a known ore source. A potential bell-shaped mining pit at Kiltera, Co. Waterford (IID:129) discussed by Scott (1990, 155) must be considered a very tentative identification, and while some evidence for the excavation of bog ore from Clonaslee, Co. Laois (Dunne 1869; Frazer 1870) was discussed in Chapter 3, it is not associated with smelting, nor is it well dated.

The rarity of ore finds is surprising considering the number of known smelting sites (38) from the study period (Table 5.1). It is rarely found and generally in very small quantities, with the possible exception of Garryduff 1, Co. Cork (IID:103) where ore was reportedly strewn all around the site (O'Kelly 1963, 103). Previously, the scarcity of ore on Irish sites could be explained as a consequence of limited excavation and specialist analysis but this is no longer the case. Clearly, iron was being smelted from ore during the study period, so the problem appears to be one of archaeological visibility. It may be that ore was very valuable and was rarely lost or discarded. However the ubiquity of discarded/lost iron artefacts on many sites in the study makes this an unlikely explanation; it is unlikely the ore would be conserved to such an extent when the metal was not. Other possible problems include the weathering/disintegration of ore over time and the identification of ore as ‘archaeological’ in the field. It is not clear to what extent possible ores are/were collected on archaeological excavations.

An alternative explanation may be the common use of bog ore for smelting. Bog ore collected from Derryarkin Bog, Co. Offaly, identified analytically as primarily goethite with some siderite (Appendix 2), took the form of an orange-brown deposit within the peat layers with a consistency varying from powder to hard lumps (Figs. 3.5-3.6). Following roasting, the ore turns red in colour and is very friable (Fig. 3.7). In either state, the ore would be very difficult to identify in an archaeological context, only showing as staining or something similar to an iron pan. Given this, the rarity of ore finds on Iron Age and early medieval smelting sites in Ireland could be a product of the widespread use of bog ore, though the evidence is not sufficient to say with any certainty. Definite samples of bog ore have been found on a tiny number of smelting sites in this study (Tables 5.2 and 5.3; Collins 1955; Young 2006d; Photos-Jones and Wilson 2007b, 219-220) but the location of many smelting sites in close proximity to bogs (Fig. 5.2), particularly in the Iron Age (see Chapter 7) may relate to use of bog ore as an ore source.
Fuel

The fuels that can be used in the iron smelting process have already been considered in detail in Chapter 3. Wood charcoal was the primary fuel used in the process throughout Europe (Pleiner 2000) and evidence for its use was found on every smelting site in this study. The only, very tentative, evidence for the use of peat charcoal on a smelting site in this study came from furnace F128, Lislackagh, Co. Mayo (IID:140). Parts of the slag block were reported to have a ‘peaty texture with abundant traces of burnt out organic matter and a low iron content’ (Walsh 1993a, 29). No evidence was found in this study for the storage of charcoal on smelting sites.

Oak charcoal was commonly used in smelting, as seen in the furnaces at Derrinsallagh 4, Co. Laois (IID:077; O’Carroll 2008b), Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006) and on smelting sites along the route of the M4 motorway including Johnstown 3, Co. Kildare (IID:118), Hardwood 3 (IID:110) and Rossan 6 (IID:179) in Co. Meath (Carlin et al. 2008b). There is also evidence for the use of other wood species. One furnace pit (F62) from Derrinsallagh 4 produced a crudely chisel-pointed post made of hazel (O’Carroll 2008b). This may have been for packing the furnace pit or was possibly a discarded post re-used as fuel. At Caherweelder 7, Co. Galway (IID:037) charcoal from a sunken pit associated with a furnace produced a small proportion of oak with a range of other tree-species more common, including significant proportions of pomoideae, hazel, alder, prunus and ash (Dillon 2010), though this could be a result of dumping or other activities. Ash charcoal was identified from one furnace (F145) at Monganstown, Co. Westmeath (IID:145), though others contained oak charcoal (Dillon 2009). Evidence for possible kindling was also identified from a furnace at Monganstown in the form of charred seed, straw, hazelnut shell and a fruit stone and from another furnace at Derrinsallagh 5, Co. Laois (IID:078) in the form of a charred sedge nutlet (Lennon 2009d, 23).

There is little clear evidence for charcoal production being carried out together with smelting in the study period. This is despite the large number of charcoal production sites identified in the last decade (cf. O’Sullivan and Downey 2009; Kenny 2010). A number of smelting sites including Aghamore, Co. Westmeath (IID:003), Hardwood 3, Co. Meath (IID:110) and Monganstown, Co. Westmeath (IID:154) did produce evidence for charcoal production but this always significantly post-dated the smelting, while other sites including Derrinsallagh 4, Co. Laois (IID:077) and Carrickmines Great, Co. Dublin (IID:043) had undated evidence. Charcoal production in archaeologically-visible pits seems to be a post-eight century AD phenomenon in
Ireland (cf. Kenny 2010, 109-110), unrelated to the smelting activity identified in this study. It is not clear where or how charcoal was produced prior to this (see discussion in Chapter 3).

Clay

There is clear evidence for the use of clay in furnace linings and superstructures (see below) but it is less clear where it was sourced. There is tentative evidence for local sourcing of clay at Monganstown, Co. Westmeath (IID:154). A series of long and thin pits between c. 0.10m and 1m in depth were identified as either ore or clay extraction pits by the excavator (Lehane 2009, 9-10). One large pit, measuring 2.2m x 1.6m x 0.3m, from Kilmacthomas Area 25, Co. Waterford (IID:125) was interpreted as a clay extraction or water storage pit, though it is not clear if ironworking activities on the site relate to smelting or smithing (Tierney 2003). The pit was not dated and no slag was found in its fill. Intrusive ‘whitish clay’, brought in from sources close to the site, was identified at St Gobnet’s House, Ballyvourney, Co. Cork (IID:186; O’Kelly 1952). However, it is not clear that smelting was definitely undertaken on the site. Overall, there is very little good evidence for the sources of clay used in smelting during the study period, though it was certainly broadly used in furnace linings and superstructure.

Tools

Smelting can be undertaken with a very basic set of tools. The most important, where a forced draught is being applied, is the bellows. To date there is no evidence for the use of clay pot or bowl-bellows in northwest Europe (Pleiner 2000, 212-213; Chirikurea et al. 2009) and most authors assume they were made from organic materials (e.g. Tylecote 1986; 1987; Pleiner 2000). Evidence for such perishable tools has not been identified in this study. Bellows could be used in conjunction with a clay or stone tuyere, but there is little evidence for these from smelting sites in this study (see discussion below).

It has been suggested that some Irish stone mortars are associated with smelting activities (Dolan 2009). Ethnographic and archaeological evidence (discussed in Chapter 3) suggests these could have played a role in the preparation of ores for smelting or in the crushing of charcoal. The crushing of ore is attested in a medieval Irish text, the Dindsenchas of Ailén Cobthaig, though it is not clear if the reference is to iron ore or that of another metal (Ó’Corráin 1974; Scott 1990, 177). However, mortars are not found exclusively on smelting sites and some can be directly related to smithing (see Chapter 6).
Direct associations between mortars and smelting could be identified on only two sites in this study. At Derrinsallagh 4, Co. Laois (IID:077) a stone of unknown type was closely associated with a furnace (F71) and it was suggested, based on its shape, that it may have been used to crush ore (Photos-Jones and Wilson 2007a). However, many of the furnaces on the site were associated with similar – though not concave – stones and it is possible its shape is incidental. Two mortars were also identified from Garranes, Co. Cork (IID:102), a possible smelting site. They were quite small, with maximum dimensions of 0.07m and 0.12m, and neither is known to have been associated directly with ironworking (Ó'Riordáin 1942, 110-111). Other similar stones (e.g. Hencken 1942, 65; Hencken 1950, 174; Fanning 1981, 136-137) cannot be directly associated with metalworking and could just as easily be pivots, lamps or mortars associated with other processes.

A number of stone mortars were also found on sites where it is possible that smelting (but also smithing) took place. At Gallen Priory (IID:101), Kendrick (1939, 5) found a large stone slab of unspecified type, with a basin c. 50cm in diameter, interpreted as an ore-crushing hollow, cut into it, surrounded by pits of iron slag and burnt earth. At Tullylish, Co. Down (IID:197) a pit from an industrial area produced a number of large unidentified boulders, one of which had an apparently artificial depression in it, identified as a potential bullaun by the excavator (Ivens 1987, 72). Smaller mortars potentially associated with smelting include a sandstone example from Cathedral Hill, Co. Armagh (IID:010; Gaskell-Brown and Harper 1984, 125) and an unidentified stone from Nendrum, Co. Down (IID:163; Lawlor 1925, 140) with red (possibly ferric) staining. All of these were associated in some way with metallurgical debris and the mortar from Nendrum appears to have been associated with some ironstone ore (Table 5.2). Overall, the evidence is ambiguous and no certain examples of mortars associated with smelting can be identified.

**Smelting Furnaces**

Smelting furnaces were identified with some certainty on 30 sites in the study, with possible furnaces identified on 46 other sites (see Appendix 5). In total, 88 furnaces were identified with 40 (45%) coming from one site: Derrinsallagh 4, Co. Laois (IID:077). Furnaces were identified based on a combination of indicators including morphological parallels with known types (discussed in Chapter 2), evidence for burning, evidence for superstructure and reported slag assemblages. Details of individual furnaces, as well as hearths and indeterminate ironworking features, are recorded in the Features Gazetteer (Appendix 5). Very few examples of Irish smelting furnaces have been identified previously in the published literature (c.f. Scott
1990,158-170; Carlin et al. 2008b; Wallace and Anguilano 2010b) and many of these have been identified as bowl furnaces. The evidence for furnace morphology and construction identified in this study is considered in detail here, providing a new understanding of Irish furnace design in a European context and a basis for future research and identification.

Plans

Furnace pits identified in the study were invariably circular, or oval/sub-circular and no clear evidence for any rectangular furnace base was identified in the data (Table 5.4). One feature (F2) from Adamstown 1, Co. Waterford (IID:001; Russell and Ginn 2007) had a sub-rectangular/oblong shape on the site plan (Fig. 5.3) but intensive burning at one end of the feature suggests the furnace pit was actually circular, with an adjacent shallow pit (this was also noted by the specialist: Young 2006e, 6).

The majority of furnaces have very simple plans with no associated features but occasionally, furnaces pits have been reported with figure-of-eight shaped plans. In most cases these are actually furnace pairs. For example, at Moyally 2, Co. Offaly (IID:157) two furnaces (F148 and F149) side by side had large red, heat-affected halos of soil, which when completely excavated gave the impression of a single, figure-of-eight shaped feature (Bayley 2007a; Fig. 5.4). At Derrinsallagh 4, Co. Laois (IID:077) two stone-lined pits were identified as a single feature, termed a double furnace. These were treated as a single feature in the final report (Photos-Jones and Wilson 2007a; Lennon 2009c), though magnetic susceptibility analysis suggested the features had been heated to very different temperatures (Wilson 2006). The large pit has been included as a furnace pit (F78) here. The smaller pit may also be a furnace, or more likely a pit or hollow associated with the larger furnace.

A small number of furnace bases have clear evidence for adjacent shallow pits associated with furnace arches (discussed further below), making them figure-of-eight shaped in plan. The best example is F41 from Derrinsallagh 4, Co. Laois (IID:077) which preserved a ‘working hollow’ connected to the furnace base by an arch wholly or partly below ground level (Young 2008a; Fig. 5.5). A similar feature may explain the unusual shapes of the furnaces from Adamstown 1 and Derrinsallagh 4 discussed above as well as a shallow ‘flue’ associated with a furnace (F168) from Trantstown, Co. Cork (IID:193). Two pits from Newtown 1, Co. Westmeath (IID:165) may represent a furnace with an adjacent pit but there is insufficient information from the site to tell (Stevens 2007d; N.R.A. 2010b).
Other furnaces are associated with large sunken areas of various types. At Caherweelder 7, Co. Galway (IID:037) the furnace (F15) was located in one corner of an irregular diamond-shaped sunken area (Hegarty 2010). A deposit of charcoal at the base of the sunken area, apparently raked from the furnace (Fig. 5.6), indicates this was some kind of working hollow. Another furnace (F94), excavated at Grange 2, Co. Meath (IID:108), was associated with a large oval hollow 2.20m in length and 1.10-1.60m in width with a depth of 0.66-0.88m (Kelly 2011a; Fig. 5.7). At Knockbrack, Co. Kerry (IID:131) two furnaces (F122 and F123) were associated with a more complicated series of working hollows (Hull and Taylor 2006). These furnaces were situated on the edge of a large sub-circular sunken area but they also had circular hollows, probably associated with arches, directly in front of them (Fig. 5.8). One feature (F121), from Kinnegad 2, Co. Westmeath (IID:130; Murphy 2003b; Photos-Jones 2003b) was made up of a sub-square hollow with one deep corner and an oxidised shelf in one of its sides (Fig. 5.9). It could not be definitively identified as a furnace, though its morphology is similar to the sunken feature from Caherweelder 7.

Profiles

Furnace pits are quite diverse in terms of their profile in comparison to their plans (Tables 5.4 and 5.5). A significant proportion (39, 44%) have very steep sides, often vertical. These straight sided pits commonly have flat (22) or concave (16) bases. A similar number (37, 42%) have less steep, sloping sides. This category includes a wide range of profiles, from heavily truncated furnace bases with short shallow sides to large furnace cuts with sides that could be described as concave. It is possible that this category is over represented where features were overcut into heat-affected halos when recorded. These tend to be thicker at the top of a cut, penetrating progressively less deep into the soil lower in the pit where the temperature would be lower (see examples below). Overcutting would thus tend to reduce the steepness of the slope, particularly near the top of a furnace pit.

Depth

 Depths were reported for 83 furnaces (recorded in the Features Gazeteer, Appendix 5) but, due to the possibility of truncation, these can only be seen as minimum depth figures. The deepest furnace pit feature (F37), from Cuffsborough 4, Co. Laois (IID:071; Murphy 2009b), is 0.60m in depth and is paired with another furnace (F36) which is 0.55m in depth. Both furnaces have irregular bases and relatively small internal diameters, giving length:width ratios of 1:1.7 and 1:1.5 respectively, assuming they are not overcut (Fig. 5.10). One furnace (F39), 0.45m in depth, from Derrinsallagh 4, Co. Laois (IID:077; Lennon 2009c) has a base clearly defined by flat, angular quartz stones, giving a maximum depth unlikely to have been
enhanced by overcutting. The average reported depth is 0.25m, almost certainly an underestimate when truncation is taken into account.

**Maximum Internal Dimension**

Reported widths of furnaces were recorded with the aim of comparing the internal size of furnace shafts (Features Gazeteer, Appendix 5). This dimension is important as it influences the capacity of the furnace shaft, the burn rate of the fuel and the number of air inlets required and is a possible indicator of different furnace technologies (see discussion in Chapter 2; Tylecote et al. 1971; Tylecote 1973; Craddock 1995; Pleiner 2000). These factors are also affected by the height of a furnace shaft, but this is rarely known archaeologically. However, reported widths from sites in this study are inconsistently reported and do not always relate to the internal width/diameter of the furnace shaft. This is due to the occasional existence of lining layers and/or a heat-affected halo of soil around the furnace pit. Ideally, the internal diameter of a furnace would be recorded along with the thickness of the lining/superstructure and, where superstructure survived, the external furnace diameter. However, in many cases only one ‘width’ was given and it is not always clear precisely what was being measured.

For these reasons, where possible, photographs, section drawings, plans and fill descriptions were examined in order to generate an estimated ‘Maximum Internal Dimension’ (MID) relating to the internal width of the furnace shaft (Table 5.6; Appendix 5). For example, furnace F63 from Derrinsallagh 4, Co. Meath (IID:077) had a reported diameter of 0.70m (Lennon 2009c, 52-53). The original measurement was based on the post-exavation diameter, including the heat-affected halo around the upper part of the furnace pit (Fig. 5.11). The section drawing (mislabelled in the original report (Lennon 2009c, Figure 24) but with matching context numbers) and photographs show the funnel shape of the final cut, caused by the excavation of the heat halo (C343), described as a reddish orange oxidised layer, which was widest at the top of the pit, close to the hot zone of the furnace (Fig. 5.11). The furnace also had a blue/grey vitrified clay lining (C342) of variable thickness forming a ring around the pit. Taking these factors into account, an MID of c. 0.30m can be estimated.

It was possible to estimate MIDs for 76 of the 88 furnaces in the study. The average, re-assessed, furnace width/diameter (MID) is 0.39m with a maximum of 0.65m and a minimum of 0.17m. The majority (56) lay in a range between 0.30m and 0.49m (Fig. 5.12), with 62 (70%) measuring between 0.30m and 0.50m. When the large number of furnaces from Derrinsallagh 4, Co. Laois (IID:077) are excluded the picture remains largely the same, with a slight shift towards bigger furnace sizes, in the range 0.40m to 0.49m (Fig. 5.13). In contrast, MIDs of
furnaces from Derrinsallagh 4 have a smaller range, with the majority between 0.30m and 0.39m, and 29 (73%) measuring between 0.30 and 0.40 (Fig. 5.14). This suggests uniformity of furnace design on the site, with some outliers.

The largest furnaces (F145 and F146) in the study came from Monganstown, Co. Westmeath (IID:154) and were reported with ‘average dimensions’ of 0.78 m by 0.61 m by 0.42 m (Lehane 2009, 7). Both furnaces were given an MID of 0.65m, though discrepancies between measurements on sections and plans from the site make these approximate figures. Nonetheless they do appear to have been very large furnace pits. Two furnaces (F28 and F171), from Cloncollog 2, County Offaly (IID:057) and Waterunder, Co. Louth (IID:201) had MIDs measuring 0.60m. The example from Cloncollog may be slightly smaller as it appears, based on photographs (Fig. 5.15), to have been slightly overcut at the top; no section drawing was available so the reported length was accepted as the MID. Overall, the internal diameters of smelting furnaces in this study rarely exceeded 0.50m but there is clear evidence for a small number of furnaces with MIDs above this.

The smallest furnace in the study (F94) came from Grange 2, Co. Meath (IID:108; Kelly 2011a) and was the only example with an intact shaft (Fig. 5.16). The shaft was directly examined for this study, following conservation (Fig. 5.17), and had an MID of 0.17m. This is significantly smaller than any of the other furnaces identified. The next smallest furnace (F124) came from Knockcommane, Co. Limerick (IID:132) and had an MID of 0.23m, estimated based on a large piece of surviving vitrified furnace wall (Molloy 2007, 43). Two furnaces (F82 and F7), from Derrinsallagh 5 (IID:078) and Ballycasey More, Co. Clare (IID:017), had MIDs measuring 0.25m, based on specialist analysis of F82 (Young 2008e) and feature descriptions and a section drawing (which indicated a clay/stone lining) of F7 (Murphy 2002). Clearly, furnaces could have very small internal diameters, as small as 0.17m, though the design of the furnace at Grange 2 is very unusual for this dataset. Most furnaces had MIDs larger than 0.23m.

Young (2003d; 2005d; 2008b; 2009a) has argued for a temporal element to the size range of furnaces with larger examples, c. 0.50m in diameter, dating to the earlier Iron Age and smaller pits, c. 0.30m in diameter, dating somewhat later. Evidence from this study suggests the picture is more complex with a range of furnace sizes occurring throughout the study period (Table 5.6). The wide date ranges of many sites makes definitive analysis difficult but there is no clear progression from larger to smaller furnaces through the Iron Age, or from the Iron Age to the early medieval period. When furnaces directly dated by materials in their fills are compared, the evidence is similarly complex with no clear progression in size (Fig. 5.18),

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though furnaces measuring over 0.40m are more common in the Iron Age. However, the lack of furnaces dated to the early medieval period mean no clear conclusions can be drawn.

Lining

There is extensive evidence for the lining of furnace pits with clay and/or stone, though unlined-pits are also common (Fig. 5.19). Clay linings are the most commonly reported. One furnace pit (F168) from Trantstown, Co. Cork (IID:193; Sherlock 2005a) preserved an intact lining of pale yellow clay, baked red in areas of high heat (Fig. 5.20), similar linings were identified on furnaces from Kilruissane (IID:127), also in Co. Cork (Sherlock 2005b). A large number of furnace pits from Derrinsallagh 4, Co. Laois (IID:077) had linings of vitrified grey clay (Lennon 2009c). The linings form rings around the furnace pits and were probably also the bases of superstructures, some of which survived partially intact (see detailed discussion below). One furnace from the site (F41) was excavated in detail off-site and while a significant thickness of lining could not be identified, it was thought that the cut had been carefully smoothed, possibly with a thin lining of clay (Young 2008a).

Stone linings are quite rare and take a variety of forms. At Tonybaun, Co. Mayo (IID:191; Nolan 2006a; Wallace and Anguilano 2010b) an unusual furnace pit, dated to the Iron Age, was lined with large stone flags, five upstanding and one forming the base of the pit with gaps filled with silt or clay (Fig. 5.21). It is reminiscent of the hellegryte discussed in Chapter 2; it was interpreted as the base of a shaft furnace by Wallace and Anguilano (2010b) and may parallel similarly dated stone-lined furnaces from Culduthel near Inverness, Scotland (Fig. 5.22), which preserved evidence for wattle and daub superstructures (Murray 2006; 2008). A stone-lined pit was also identified from Phase 2 at St Gobnet’s House, Co. Cork (IID:186), though there is insufficient information to identify its function (cf. O’Kelly 1952).

Three furnaces have a single flat stone lining the base of their pits. This includes two identical, paired furnaces from Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006), which also had clay lining both the stones and the sides of their pits, as well as one example (F59) from Derrinsallagh 4, Co. Laois (IID:077; Lennon 2009c). Other furnaces from Derrinsallagh 4 (F39, F46, F48, F60 and F78) had partial, irregular stone linings, though it is not clear to what extent these were deliberate.

The use of stone and clay linings represent particular design choices, possibly related to function, but also technological traditions. No clear chronological or geographic pattern in the use of linings could be seen in the data from this study. However, the stone-lined furnaces
from Tonybaun and Culduthel may indicate an approach to smelting prevalent in the Iron Age in Ireland and Scotland, though the evidence is very limited.

Superstructure

Recent excavations have, for the first time, provided clear evidence for the use of furnace superstructures in Ireland. The evidence comes primarily from two sites: Grange 2, Co. Meath and Derrinsallagh 4, Co. Laois, but less direct evidence from a number of other sites suggest the use of superstructures of various sizes and designs.

Grange 2

Excavations at Grange 2, Co. Meath (IID:108; Kelly 2011a; Wallace and Anguilano 2011), uncovered an intact furnace shaft standing 0.40m high following conservation (Fig. 5.17) at one end of a large sunken pit (Fig. 5.7). The shaft was built into the wall of the pit and had a crudely finished arch at its base. The front face of the furnace measures between 0.10m and 0.15m thick after conservation. This is not a slag-tapping furnace with flows tapped at intervals into a channel in front of the furnace (Wallace and Anguilano 2011). Instead, the slag would have collected in the base of the furnace and been removed through the arch following a smelt; remains of this raking out can be seen as a dark linear deposit in front of the furnace (Fig. 5.8). Unusually, the base of the furnace, which was probably lined with clay, is vitrified (Figs. 5.16 and 5.17), indicating prolonged high temperatures during its use. It is likely that the furnace underwent multiple smelts, generating a large amount of slag (42.68kg) for such a small furnace (Wallace and Anguilano 2011). The broken edges at the top of the furnace shaft (Fig. 5.16) indicate it has not been preserved to its full height.

The design of the Grange 2 furnace is similar in some respects to Romano-British ‘Ashwicken Type’ furnaces (Gibson-Hill 1980, 21-22) found on sites in England (Tylecote and Owles 1960; Gibson-Hill 1980; Tylecote 1986, 157-158; Hall et al. 2006; Hall 2008). A later embanked furnace from Ramsbury, Wiltshire is much later, dating to the eighth or ninth century AD, and is slag-tapping (Haslam et al. 1980; Tylecote 1986, 180-182). The Grange 2 furnace probably dates to the fifth or sixth centuries AD (Kelly 2011a) and it is therefore unlikely that its design is directly related to these furnace types. Similar embanked shaft furnaces are also known from central Europe, dating from the Iron Age right through to the early medieval period (Pleiner 2000, 176-178).
Derrinsallagh 4

The large group of furnaces excavated at Derrinsallagh 4, Co. Laois (IID:077; Wilson 2006; Photos-Jones and Wilson 2007a; Young 2008a; 2008d; Lennon 2009c) included a number of furnaces with partially intact superstructure. These furnaces seem to share a similar design: bowl shaped pits with sunken arches leading to adjacent working hollows. Evidence for superstructure consists of short, thin vitrified sections, often sloping in towards the centre of the furnace and not vertical. The surviving sections of superstructure may have been below ground level when constructed, aiding their survival.

One furnace from Derrinsallagh 4 (F41) was excavated off-site by a specialist archaeometallurgist (Young 2008a). This had clear evidence for a sunken arch, adjacent working hollow and also for two blowholes, confirming the use of forced draught. The blowholes represent at least two separate smelting episodes, with the first located at right-angles to the arch and the second directly opposite (Fig. 5.5). A large slag mass attached to the second blowhole may have been the reason the furnace was abandoned. Young (2008a) suggested the furnace wall was c. 0.10m thick and reconstructed it as a freestanding shaft furnace with an overhang at its base leading to vertical walls (Fig. 5.23). Evidence from other furnaces on the site suggests their superstructures may have been domed or funnel-shaped. Three other furnaces (F44, F48 and F54) were found in close proximity to F41 and seem to have had similar designs.

A group of three furnaces (F66, F67 and F68) located approximately sixty metres to the north of F41 (Fig. 5.24) had better preserved superstructure but did not benefit from off-site specialist excavation. Both F66 (Fig. 5.25) and F67 (Fig. 5.26) have, based on photographs, substantial sections of surviving furnace wall ringing 60-70% of their circumferences, with gaps indicating the location of arches. In situ slag attached to the northern wall of F66 suggests it was blown at right-angles to the arch. Similar evidence suggests the blowhole on F67 was situated opposite the furnace arch. The third furnace in the group (F68) is more difficult to interpret as it has an unusual protrusion on its west side, possibly forming a narrow channel (Fig. 5.27). This is likely to be an arch but was interpreted as an opening for the use of a tuyere by Wilson (2006). Photographs of F68 (Fig. 5.27) suggest the surviving overhanging superstructure was as thin as 0.02m and the base of the furnace walls (C415) seen in the section of F66 (Fig. 5.25) was slightly thicker, c. 0.05m.

Some other furnaces from the site had evidence for less well-preserved furnace walls. F62, also part of a group of three furnaces, had surviving superstructure around parts of its
circumference and also has very clear evidence of a raking area/working hollow to its west (Fig. 5.28). F62 appears to have had steep sides and a flat base, unlike the more concave profiles of those above. Another group of three furnaces (F61, F72 and F73) are probably similar in design to F66, F67 and F68, though they were more truncated. Small amounts of upstanding superstructure survived on at least six other furnaces from Derrinsallagh 4 (see Features Gazeteer, Appendix 5).

Not all furnaces from Derrinsallagh 4 conformed to the design of those above. For example, a pair of furnaces (F52 and F53) excavated in an extension to the north of the site had steep sided profiles, though a fragment of furnace wall with a blowhole from one of their fills suggests an overhanging wall similar to those above (Young 2008d). Another furnace (F63) had a substantial vitrified clay ring visible around its circumference and a probably in situ slag block on one side (Fig. 5.11). It had a steep, almost conical cut in section (Fig. 5.11), very different to those above. Other furnaces from the site were not sufficiently well-preserved to identify their design.

Other Sites
No other sites in this study had intact superstructure, but indirect evidence for arches in the form of adjacent hollows or charcoal/slag spreads was preserved in some cases. The evidence from Knockbrack, Co. Kerry (IID:131), Trantstown, Co. Cork (IID:193), Adamstown, Co. Waterford (IID:001), Newtown 1, Co. Westmeath (IID:165) and Caherweelder 7, Co. Galway (IID:032) was discussed earlier in the chapter. An orange clay 'lid' from Trantstown (furnace F168) represents further evidence for superstructure from the site (visible in the pre-excavation photograph: Fig. 5.20), probably the collapsed walls of the furnace (Sherlock 2005a). Postholes flanking the two furnaces at Knockbrack, Co. Kerry (IID:131) may relate to superstructures, though they may also relate to bellows or some form of structure (Hull and Taylor 2006, 17). No evidence was found on other sites in this study for the use of post/wattle skeletons to support clay superstructures.

Air Supply
Oxygen can be introduced to a furnace using either forced or natural draught. Natural draught relies on the ‘chimney effect’ drawing air into the furnace at its base, with the exception of wind-powered furnaces unlikely to have been used in Ireland (see discussion in Chapter 2). For the ‘chimney effect’ to draw enough air to complete a smelt, a shaft height of c. 1.5m or above is required (Pleiner 2000, 196-197). The original superstructure height is not known for any of the sites in this study, making identification of natural draft extremely difficult. The furnace
shaft from Grange 2, Co. Meath (IID:108), preserved to a height of c. 0.40m, could originally have been substantially taller and might have used a natural draught. The deep pit into which the furnace was set may have provided stability/support, enabling the construction of a longer shaft. No blowhole was identified on the furnace (Wallace and Anguilano 2011), though it could have been blown through the basal arch using a forced draught.

Forced draught requires the use of bellows, often in conjunction with clay tuyeres (as in smithing: see Chapter 6). No tuyeres were identified at Grange 2 and there is very little evidence for their use on smelting sites in this study, coming only from Carrigoran, Co. Clare (IID:044; Reilly 2000a; 2000b; Young 2005a), Garryduff, Co. Cork (IID:103; O’Kelly 1963), Clonmacnoise, Co. Offaly (IID:060, 063; Ó’Floinn 1987-88; Manning 1990; King 1993) and Ballykilmore 6, Co. Westmeath (IID:025; Young 2006d; Channing 2007; Young 2009a). All of these sites also had clear evidence for smithing, and sometimes non-ferrous metallurgy, and it is likely that the tuyeres found on them relate to these processes (see further discussion in Chapter 6). However, there is good evidence for blowholes in the walls of some furnaces. Blowholes are channels created in the furnace wall through which air is blown. The available evidence (discussed below) points to furnaces blown through blowholes, usually from one side and perhaps through only one blowhole.

Evidence for blowholes from Derrinsallagh 4, Co. Laois (IID:077) has been discussed above and includes sequential use of two blowholes on one furnace (F41), as well as evidence for blowholes in the form of in situ slag blocks, differential vitrification or blowhole fragments from a number of furnaces (e.g. F63, F66, F67, F69, F71; see Features Gazetteer, Appendix ?). A number of the blowholes from Derrinsallagh 4 were in overhanging walls, at an angle of c. 30-40° in the case of F41 (Young 2008a). The morphology of in situ slag blocks from furnaces on a number of other sites, including Tullyallen 6, Co. Louth (IID:196), Adamstown 1, Co. Waterford (IID:148) and Lislackagh, Co. Mayo (IID:140) also suggest the use of single blowholes (Walsh 1993a; Young 2003c; 2006e). No clear evidence for the simultaneous use of multiple blowholes has been identified as yet from Ireland, though the slag cake from Adamstown may have been associated with two blowholes (Young 2006e).

Fragments of clay from around blowholes have been reported from a number of sites including illustrated examples from Johnstown 1, Co. Meath (IID:117) and Waterunder, Co. Louth (IID:201). The example from Waterunder (Scully 2010) may actually be a tuyere tip with a conical perforation (Fig. 5.29). The examples pictured in the specialist report from Johnstown 1 (Photos-Jones 2003d) are similarly ambiguous and could potentially be tuyeres (Fig. 5.30). The
examples from both sites were found in contexts that had unclear functions, though the piece from Waterunder was identified as probable dump material (Scully 2010).

**Blooms and Slag**

The goal of smelting is to produce a raw bloom of iron and slag that can be worked into whatever tool, weapon or other artefact is required. The bloom extracted from the furnace is unconsolidated, containing significant amounts of slag. Blooms are very rare finds on smelting sites in this study, though a small number of unconsolidated blooms have been reported. Scott (1990, 162) identified two fragments of a small unconsolidated bloom from Ballyhenry, Co. Antrim (IID:024) weighing only 250gm. At least two unconsolidated blooms have been identified from recently excavated sites, at Knockcommane, Co. Limerick (IID:132; Molloy 2007; Photos-Jones 2007b) and Hardwood 3, Co. Meath ((IID:110; Photos-Jones 2003a; Murphy 2004b). The first had a ‘bird’s nest’ shape and weighed 1390g, with c. 800g of metallic iron and was found in the fill of a gully (dated to 358-47 cal. BC) surrounding a post-built structure and smelting furnace (Molloy 2007; Photos-Jones 2007b). Two weathered fragments of blooms, enveloped in slag, were identified from unknown contexts at Hardwood 3 (Photos-Jones 2003a; Murphy 2004b). Fragments of iron bloom were reported from Knockmore, Co. Antrim (IID:134; Nicol and Barkley 2010), though no details are available. Similarly, ‘raw bloom’ is reported from Killoran, Co. Tipperary (IID:123) but no details or specialist analysis is available (Cross-May et al. 2005, 309).

Slag is generated as a by-product of smelting and was found on all smelting sites in this study (see Sites Gazeteer, Appendix 5). Slag from individual furnaces has not been directly analysed for this study, with the exception of Mackney, Co. Galway (IID:149; Appendix 1), analysed as part of a semester of archaeometallurgical training in the Institute of Archaeology, University College London. It is beyond the scope of this study to attempt an in-depth characterisation of Irish smelting slag, but some general observations can be made based on recent work. In general, smelting furnaces in this study seem to have produced slag cakes, often broken up, of varying sizes and shapes, miscellaneous amorphous slags and fluid, drippy prills or ‘run’ slag (e.g. Young 2005d; Keys in Hull and Taylor 2006, 43-49; Cruickshanks and McLaren 2009). These were predominately produced in slag-pit furnaces and some slag preserved, as voids, moulds of the wood used to pack the furnace pit (Young 2003c; 2005a; 2009b). There is variation in slag morphology between sites and technologies as well as variation in terminology and interpretation between specialists.
Tap slags form where slag is allowed to flow from a furnace at intervals during a smelt, into a tapping channel or pit (see Chapter 2). They are very distinctive, taking the form of the channel or pit they are tapped into and with distinctive flowed surfaces. There is no convincing evidence for tap-slags from sites in this study, though a small number of sites refer to possible examples. For example eight pieces of ‘cinder/tap slag’ were recorded from Cathedral Hill, Co. Armagh (IID:010; Gaskell-Brown and Harper 1984), and one possible piece was reported from Bofeenaun, Co. Mayo (IID:031; Keane 1995, 173-174). Tap slag was identified by Fairburn (2005a; 2005b; 2006) from a number of sites including Corrin 1, Co. Cork (IID:068), Lisnagar Demesne 1, Co. Cork (IID:143) and Monganstown Co. Westmeath (IID:154), though no photographs are available to confirm the identifications. The examples from Monganstown were analysed further and proved to be non-tapped slag (Martinón-Torres 2009). Tap slag identified by Scully (2010) from ‘bowl furnaces’ at Waterunder, Co. Louth (IID:201) is, based on photographs of the material (Fig. 5.31), actually prilly run slag, probably from the base of a slag-pit furnace.

Possible tapping pits were identified at Knockbrack, Co. Kerry (IID:131). Shallow pits in front of the furnace pits at Knockbrack, Co. Kerry (IID:131) contained fragments of ‘run slag’ (Hull and Taylor 2006). This might represent broken-up tap slag, though it could also result from the raking out of fluid slag. A possible tapping pit was also identified at Newtown 1, Co. Westmeath (IID:165) but there is insufficient information from the site to confirm the identification (Stevens 2007d; N.R.A. 2010b). The shaft furnace at Grange 2, Co. Meath had an associated ‘raking out/tapping pit’, but the slag from the site was ‘drippy and blocky’ and not classic tap slag, suggesting the furnace was not tapped, despite producing a very fluid slag (cf. Wallace and Anguilano 2011).

**Associated Features and Structures**

A furnace is the only feature required to smelt iron; technically, no additional shelter, pits, hollows etc. are needed. However, furnaces did not always exist in isolation; some were associated with quite ephemeral features, some were in proximity to substantial structures and a few may have been located within structures. There is no evidence for features or structure types – besides furnaces – that are consistently associated with smelting in Ireland. Nonetheless a number of smelting sites did have distinctive associated remains. These sites will be discussed in broad chronological order, based on the five chronological phases (outlined in Chapter 4) used for the project. Smelting sites identified in this study were not
distributed evenly across time; there is a significant bias towards sites from the Iron Age (Table 5.7, Figs. 5.32-5.34).

Bronze Age/Early Iron Age (pre c. 400 BC)

Very few sites are dated with any certainty prior to c. 400 cal. BC. At Adamstown 1, Co. Waterford (IID:148; Russell and Ginn 2007) two smelting furnaces (F1 and F2) were located within a large Middle Bronze Age hut/house (Fig. 5.3). However, the furnaces were stratigraphically isolated and only one, possibly intrusive, piece of slag could be related stratigraphically to the structure (Young 2006e). It is very unlikely that iron smelting on the site was contemporary with the Bronze Age activity. Only one smelting site, Ballydavis 3, Co. Laois (IID:022), is closely dated to the Early Iron Age and, while two furnace pits were identified (F10 and F11), no evidence for any accompanying structures was identified by the excavator (Ó’Maoldúin 2010). This site was located in close proximity to a large Iron Age hilltop enclosure with burial, ritual and possibly settlement activity, and is discussed further in Chapter 7. There is some evidence for smelting, in the form of stray slag, within the enclosure at Ballydavis 2 (IID:021) but it is not closely dated. Smelting was also recorded in close association with an Iron Age burial monument at Tullyallen 6, Co. Louth (IID:196), though the furnace itself is not dated (Campbell 2003; Young 2003c).

A number of potentially early sites including Rossan 6, Co. Meath (IID:179; Murphy 2004c), Newtown 1, Co. Westmeath (IID:165; Stevens 2007d; N.R.A. 2010b), Johnstown 3, Co. Meath (IID:118; O’Hara 2002; Photos-Jones 2003d), Derrinsallagh 5, Co. Laois (IID:078; Young 2008e; Lennon 2009d) and Cherryville Site 12, Co. Kildare (IID:052; Breen 2005) have very little evidence for associated features or structures.

Developed Iron Age (c. 400BC – c. 0 AD)

A substantial number (20, 50%) of the smelting sites in the study potentially date to the last four hundred years of the first millennium BC (Table 5.7), more than to any other phase. A significant number of these sites, including Cloncollog 2, Co. Offaly (IID:057; Clark 2008), Kilrussane, Co. Cork (IID:127; Sherlock 2005b), Monganstown, Co. Westmeath (IID:154; Lehane 2009), Hardwood 3, Co. Meath (IID:110; Murphy 2004b), Newrath, Co. Kilkenny (IID:164; Wilkins 2006), Ballycasey More, Co. Clare (IID:017; Murphy 2002; 2004a), Tonybaun, Co. Mayo (IID:191; Nolan 2006a), Trantstown, Co. Cork (IID:193; Sherlock 2005a) and Moyally 2, Co. Offaly (IID:157; Bayley 2007a; Photos-Jones 2008b) are isolated with little or no evidence for associated features beyond stray pits and postholes.
Good evidence for a substantial structure associated with a smelting furnace was identified at Knockcommane, Co. Limerick ([IID:132; Molloy 2007; Photos-Jones 2007b]). The structure consisted of a discontinuous ring of gullies enclosing a smaller ring made up of a number of postholes and a gully (Fig. 5.35). The furnace was located close to the centre of the site; radiocarbon dating and slag located in some of the gullies suggest it was contemporary with the structure (Molloy 2007). The entire site may have been roofed, giving a building with a diameter of 15m, or the outer gullies may represent some form of enclosure with a roofed structure c. 8.5m in diameter within it. Stakeholes within the central ring may have formed internal divisions or furniture (Molloy 2007).

Lislackagh, Co. Mayo (IID:140) also produced evidence for an association between a furnace and, in this case, three circular structures, two of which had slag in the upper fills of their ditches (Walsh 1993a; Fig. 5.36). The site was also enclosed by a circular ditch. Some doubt has been placed on the veracity of the Iron Age radiocarbon dates for the structures, since Early Medieval dates were attained for finds from the enclosing ditch (see Walsh 1993a; Ó’Drisceoil 2007b, 22-23). At Carrickmines Great, Co. Dublin (IID:043; Young 2003a; Ó’Drisceoil 2007b) a furnace (F16) was located 15m to the west of a round hut/house c. 5m in maximum diameter (Fig. 5.37). Radiocarbon dates from the site suggested the furnace, hut/house, a fence line and a rectangular structure (2m x 2.3m) may have been contemporary, dating sometime between c. 400 BC and c. 100 AD (Ó’Drisceoil 2007b, 22).

Late Iron Age (c. 0 AD – c. 400 AD)

Only one smelting site, Cuffsborough 4, Co. Laois (IID:071; Murphy 2009b; Young 2009c), has a date span firmly within the Late Iron Age (Table 5.7). The site included a pair of smelting furnaces but no evidence for any related features or structures (Murphy 2009b). A small number of sites span both the Developed and Late Iron Ages (Table 5.7). Of these, Waterunder in Co. Louth (IID:201) had furnaces spatially associated with circular structures, but these predate the smelting activity (McQuade 2005; 2006). Similarly, a circular structure from the large smelting site at Derrinsallagh 4, Co. Laois (IID:077) dates substantially earlier than the furnaces (Lennon 2009c). Leap 1, Co. Laois (IID:138) included one definite furnace as well as a number of pits probably associated with the smelting activity dated to these periods (Kane 2009).

Caherweelder 7, Co. Galway (IID:037), tightly dated to the first centuries BC/AD (Hegarty 2010), had a large sunken area associated with a furnace (discussed above; Fig. 5.6). It had no evidence for an upstanding structure or other associated features. However, the site is important because the design, with a furnace cut into the edge of a working hollow,
foreshadows similar, but later, smelting complexes at Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006) and Grange 2, Co. Meath (IID:108; Kelly 2011a).

Early Medieval A (c. 400 AD – c. 650 AD)

A large proportion of sites in the study date to the Early Medieval period (Fig. 4.9), but few of these have evidence for smelting (Table 5.7). The remains associated with smelting in this period show some evidence of both continuity and change. For example, at Dollas Lower, Co. Limerick (IID:081), dated between 415-585 cal. AD, a smelting furnace and a large refuse pit were identified in association with a single posthole and no clear structures; this is an apparently isolated smelting site (Dowling and Taylor 2007; Fig. 5.38), similar to many in the Iron Age (referred to above).

The furnace complex from Grange 2, Co. Meath (IID:108), discussed in detail above and probably dating between 427 and 555 cal. AD, is substantially different to previous smelting sites, in that it was built into the side of a large sunken pit and had a surviving clay superstructure, though arguably the sunken pit associated with the furnace is reminiscent of the Iron Age furnace complex at Caherweelder 7, Co. Galway (IID:037; Hegarty 2010; discussed above). Smelting evidence from Ballykilmore 6, Co. Westmeath (IID:025; Channing and Quinney 2006; Young 2006d; Channing 2007; Young 2009a), which did not include a furnace, was found on the site of a later stone church and burial ground and dated between the fifth and seventh centuries. A final report for the site is not available at time of writing, and the character of the site in its early phase is not entirely clear, though the presence of early burials and a later church suggest a possible church site or Christian burial ground (Channing 2007).

The furnace pair from Knockbrack, Co. Kerry (IID:131) are a little later than Grange 2, dating probably between the sixth and seventh centuries AD (Hull and Taylor 2006, 20). The site is more complex, with a second, stone-lined, sunken hollow connected to the main one and evidence for intense in situ burning, possibly associated with smithing. A smithing area was also identified c. 20m from the main furnace complex. Smelting and smithing was also present at Coonagh West, Co. Limerick (IID:067; Taylor 2007; Keys 2010), a large ditched settlement enclosure with a rectangular, post-built structure at its centre dated artefactually to the sixth/seventh centuries AD (Kate Taylor 2011 pers. com.). There does not appear to have been any structures directly associated with the ironworking (though post-excavation analysis is ongoing).
Early Medieval B (c. 650 AD – c. 900 AD)

Only two sites closely dated to the latest phase of this study have clear evidence for smelting. A small amount of slag together with some iron ore were identified in ditches around an enclosed settlement with attached field boundaries dating between the seventh and ninth centuries AD at Dun Emer, Co. Dublin (IID:090; Photos-Jones and Wilson 2006a; Giacometti 2007b). At Garryduff 1, Co. Cork (IID:103; O’Kelly 1946; 1963), dated artefactually between c. 650 and 750/800 AD, specimens of ore and roasted ore were identified (Table 5.2). No definite furnace can be identified, though a number of smelting pits were reported; no structures could be directly related to ironworking but the site was surrounded, at least initially, by a substantial bank with a palisade and evidence was found for house structures within the enclosure (O’Kelly 1963).

Two sites, Mackney, Co. Galway (IID:149) and Carrigoran, Co. Clare (IID:044), had chronologies later in the early medieval period but also extending later than the study period (Reilly 2000b; 2000a; Delaney 2009a). Mackney produced an unusual furnace pair with an adjacent pit creating a trefoil arrangement (Fig. 5.39; Kearns 2007; Delaney 2009a). The furnaces might potentially predate the construction of an enclosure around the site, and multiple pits and postholes in the ironworking area probably indicate a structure, though it is not clear if it was contemporary (Delaney 2009a). Excavations at Carrigoran revealed some smelting, but primarily smithing, in the context of a stone-built field system (Young 2005a). An unusual linear stone feature near a circular ironworking pit (F18) with flanking upright slabs and a flat slab at one end may be linked to the ironworking on the site (Fig. 5.40; Fiona Reilly 2010 pers. comm.).

A small number of sites with good evidence for smelting could only be dated broadly to the early medieval period. At Oldcourt, Co. Cork (IID:167; Murphy 1961), a classic uni-vallate ringfort, a small amount of slag was identified as well as some roasted ore (Table 5.2), but no furnace was identified. The settlement had evidence for two oval structures and multiple hearths and postholes (Murphy 1961). At Ballyhenry in Co. Antrim (IID:024) two enclosures were excavated, as well as ironworking evidence in the form of slag, ore and unconsolidated bloom; unfortunately no details are available about the contexts of the ironworking remains (Lynn 1983, also Scott 1990, 162). Very significant quantities of smelting slag have been identified from Clonmacnoise, Co. Offaly (IID:063) during excavations for a water treatment plant, though no structures or furnaces could be associated with it (King 2004; Young 2005h; King 2006; 2009). The dating of these sites, based on site morphology and wider dating of
settlement enclosures and monastic sites makes the dating of ironworking from them quite tentative.

Summary and Key Findings

Previous understandings of early Irish smelting have revolved around the concept of a simple, bowl-furnace technology that clung on, a relic, in a peripheral country on the edge of Europe (see Chapter 1). The sites reviewed for this study have provided a much richer view of the archaeology of iron smelting than has been available in the past and have contributed a new understanding of Irish bloomery iron smelting in the Iron Age and early medieval periods. The key aspects of the smelting technology reviewed here are summarised below.

This new analysis and characterisation of the archaeology of Irish iron smelting in the study period is extremely important as it provides a sound basis for the understanding of sites excavated in the future, both in Ireland and elsewhere. A thorough understanding of the archaeology of smelting may also, with further refinement, lead to the identification of regional technological traditions relating to past economic, cultural or political divisions. This new understanding of smelting technology, combined with the similar review of smithing sites in Chapter 6, is the basis for the more socially focussed analysis of the evidence undertaken in Chapters 7 and 8.

Raw Materials

Early smelters exploited a number of different ore sources. Very little evidence is available for the types of ore being used, though the proximity of many smelting sites to bogs provides circumstantial evidence that bog ore may have been important. Finds of ore on smelting sites in the study is surprisingly rare and this may relate to difficulties in recognising friable and/or weathered bog and other ore as well as the identification and collection of ore in the field and the rarity of lab assessments of possible samples. Our understanding of fuel use in early smelting is not complete but the evidence suggests that, where analysed, it relied almost exclusively on wood charcoal, often oak, with the use of other species including ash and hazel.

There is no reliable evidence for the clay sources used in furnace construction. Similarly, there is very little evidence for the tools used in smelting in Ireland, and while there may be some association between stone mortars and smelting sites (Dolan 2009), the evidence is not strong.
Smelting Furnaces

A large number of smelting furnaces (88) have been identified from smelting sites in the study. The remains of these furnaces generally consist of circular or oval pits of varying profile, sometimes with associated working hollows/raking pits. These features represent the basal pits of non-tapping furnaces with superstructures of various sizes and, probably, shapes. A small number were associated with large sunken hollows of varying complexity. The average reported depth of furnace pits is 0.25m, though recorded depths would, in many cases, have been subject to truncation. The deepest pit recorded measured 0.65m, though most furnaces were probably no deeper than 0.45m.

The internal diameter/width (Minimum Internal Dimension) of furnaces, excluding superstructure and heat-affected halos, was estimated for 79 furnaces giving an average of 0.39m with a maximum of 0.65m and a minimum of 0.17m. The majority of furnaces fell in the range 0.30m to 0.50m. No evidence was identified for a chronological pattern in the size of furnaces, though the broad date ranges from many sites make interpretation difficult.

Extensive evidence was found for the use of both clay and stone linings in furnaces, though many had no evidence for any lining. Limited evidence was identified for furnace superstructures, though a number of furnaces had good evidence for the existence of arches associated with raking/working hollows of various sizes and shapes. An intact cylindrical furnace shaft was preserved at Grange 2, Co. Meath (IID:108; Kelly 2011a) set into the side of a large sunken area. The shaft was preserved to a height of 0.40m and had an arch at its base for the removal of bloom and slag. Evidence from furnaces at Derrinsallagh 4, Co. Laois (IID:077; Lennon 2009a) suggested some furnaces may have had domed or funnel shaped superstructures.

Very little evidence was found for the use of tuyeres with smelting furnaces in the study (contra Scott 1990, 162-167). It is possible that some furnaces, such as the example from Grange 2, Co. Meath (IID:108; Kelly 2011a), could have used a natural draft, though it could also have been blown through its basal arch. Other sites produced clear evidence for blowholes associated with the use of a forced draft and, in at least one case, the movement of the blowhole location between smelts. No evidence for the types of bellows used was identified.
Blooms and Slag

A small number of unconsolidated blooms were identified on sites in the study, with the smallest weighing 250g and the largest 1390g. It is not clear if these represent typical blooms from the period but the fact that they were discarded suggests they may be smaller examples, either not worth processing or difficult to identify amongst the slag from a smelt. Slag from sites in the study was consistent with the use of a non-slag tapping technology. Some possible tap slags were reported but there was no evidence for classic tapping technology where slag is tapped at intervals over a long smelt into pre-prepared channels and hollows.

Features and Structures

The majority of furnaces and smelting sites in this study pre-date the early medieval period but very few of them were associated with substantial structures, apart from stray pits and occasional post or stakeholes. The majority of Iron Age smelting sites were mono-functional, isolated sites with single or paired furnaces probably operated over short periods. One exception to this was Derinsallagh 4, Co. Laois, (IID:077), currently a completely unique site in an Irish context, which produced a minimum of 40 smelting furnaces in clusters over a large area. The furnaces were not associated with any other substantial structures (Lennon 2009c).

A small number of Iron Age sites have evidence for smelting associated with burial monuments and/or circular structures of various sizes. It is not clear what functions these structures served but most of them probably did not relate directly to the smelting process. One exception may be the circular structure from Knockcommane, Co. Limerick (IID:132; Molloy 2007) which seems to have enclosed and probably covered the furnace located within it. Evidence discussed in Chapter 7 for the ritual and symbolic importance of ironworking in the Iron Age might indicate a religious role for such circular structures, echoing perhaps the later ‘pagan sanctuary’ identified by Ó’Floinn (2000) on Freestone Hill, Co. Kilkenny (IID:099; Raftery 1969).

One Iron Age site, Caherweelder 7, Co. Galway (IID:037; Hegarty 2010), which produced an isolated furnace set into the wall of a large sunken area, may have been a precursor to later, early medieval, sunken furnace complexes. Significantly fewer smelting sites and furnaces are known from the early medieval period. Smelting continued to take place in isolation in the period, particularly in the first half. Two sites: Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006) and Grange 2, Co. Meath (IID:108; Kelly 2011a) indicate a change in the technology and practice of iron smelting in the period. These sites had more complex layouts than preceding
examples, with sunken working areas and, in the case of Knockbrack, associated smithing (Hull and Taylor 2006).

Other smelting sites in the early medieval period, particularly in the second half, were located in association with settlements, both secular and ecclesiastical. This change in the location of smelting represented a distinct break with past practices. There is no evidence for the association of smelting with particular building types, instead smelting, where seen, appears to have been carried out in close proximity to houses and other structures.
6. **THE ARCHAEOLOGY OF EARLY IRISH SMITHING**

This chapter re-assesses and characterises the surviving evidence for smithing practice in Ireland during the Iron Age and early medieval periods. Iron smithing is the process of hammering and shaping that transforms a raw bloom into a finished object (see Chapter 2). It is divided into two stages: primary (bloom) smithing and secondary (black) smithing. Primary smithing involves the consolidation of the bloom: the expulsion of unwanted slag, creating a largely slag-free billet first and ultimately a piece of bar-iron ready for blacksmithing (cf. Crew 1991, 29-35). Secondary smithing refers to all the various processes used by a blacksmith to transform a piece of iron into a weapon, tool or other object (Scott 1990, 21-26; Pleiner 2000, 53-70).

Smithing has left clear traces in the archaeological record and while some of the methods and techniques used by early smiths can be reconstructed through the examination of their products (e.g. Scott 1990; Hall 1991; 1995), the focus here is on the archaeology of smithing sites. Definite smithing was identified on a large number (59) of sites in this study, spread across Ireland (Fig. 6.1), though the differentiation of primary and secondary smithing was less successful (Fig. 6.2, Table 6.1), primarily due to a frequent lack of detailed slag analysis.

**Fuel**

Wood charcoal was the dominant fuel on the vast majority of smithing sites in this study, though some sites had evidence for the use of peat charcoal. Like smelting sites (discussed in Chapter 5), a small number of smithing sites had evidence for charcoal production, though none was clearly contemporary with the ironworking activity. Species identification of charcoal was not available for all sites but observations can still be made regarding the species used in smithing. Limited evidence was identified for the use of peat charcoal on smithing sites but this may have been under-identified archaeologically as it is not as durable as wood charcoal.

**Charcoal Production**

A number of smithing sites, had possible evidence for charcoal production contemporary with smithing activities. At Raystown, Co. Meath (IID:175; Seaver 2005b; 2006; Seaver 2009a; 2010; In Prep) a charcoal clamp, containing large amounts of oak charcoal, was assigned to the same period (seventh to ninth centuries AD) as the limited smithing evidence found on the site,
though it does not appear to have been directly dated (Seaver In Prep). One pit from Carnmeen, Co. Down (IID:040; Cruickshanks and McLaren 2009; Masser and Dalland 2010) was interpreted as a charcoal kiln. It had a layer of charcoal at its base which was ‘well preserved’; presumably indicating large charcoal fragments survived (Cruickshanks and McLaren 2009). While it was undated, two fragments of SHC were recovered from upper, plough disturbed, layers in the pit providing a possible link with ironworking activity on the site.

Similar, undated, evidence for charcoal production was identified in association with smithing at Cherryville Site 12, Co. Kildare (IID:052; Breen 2005) and Rinnaraw (IID:177; Comber 2006b), Co. Donegal and from a possible smithing site at Dooey (IID:082; Ó Riordáin and Rynne 1961; Greene 2009), also in Co. Donegal (see Table 6.2). At Castlefarm 1, Co. Meath (IID:048; O’Connell and Clark 2009; O’Connell 2009), Monganstown, Co. Westmeath (IID:154; Lehane 2009) and Glebe, Co. Dublin (IID:104; Seaver 2007a; 2009b) clear evidence for charcoal production was identified but dating evidence indicated it post-dated ironworking activities.

Overall, there is little evidence that smithing accompanied charcoal production, which presumably took place close to wood sources. However, there are issues with dating such sites, often through radiocarbon dates on long-lived wood species which can skew results (Warner 1990). It is also possible that the production of charcoal in pits was a relatively late phenomenon, beginning in the latter part of the early medieval period (cf. Kenny 2010, 109-110). Earlier charcoal making appears to have left little or no trace in the archaeological record, possibly due to the use of surface-methods of production (see previous discussions in Chapters 3 and 5).

Species Selection

Oak charcoal was common on smithing sites in this study, in both the Iron Age e.g. Chapelbride 1, Co. Meath (IID:051; Danaher and Ginn 2008) and the early medieval period e.g. Lowpark, Co. Mayo (IID:148; O’Carroll 2008a). However, other species were also used. For example ash was used for smithing (and possibly smelting) at Killickaweeny 1, Co. Kildare (IID:122; O’Carroll 2006). Ash was also identified in a pit with ironworking slag from Johnstown 1, Co. Meath (IID:117), though oak was the dominant species associated with ironworking features on the site (O’Carroll 2003). Alder was identified from two samples from the fill of F127, one of the smithing hearths from Lisanisk 2, Co. Monaghan (IID:139), though no other charcoal analysis was undertaken and these may not be representative of the full range of charcoal present in the ironworking area (O’Carroll 2010). Analysis of pollen from bogs in the vicinity of a ringfort with evidence for smithing from Island West, Co. Galway (not included in this study)
demonstrated a decline in birch, with oak, hazel, elm and ash also used, to a lesser degree (Grant 2004, 261).

The identification of wood species used for charcoal on ironworking sites was not a primary goal for this project but it is clear that particular species, commonly oak but also alder, birch and ash were selected. Some evidence for the use of kindling came in the form of ribwort plantain seeds found in the fill of the hearth (F21) from Chapelbride 1, Co. Meath (IID:051; Danaher and Ginn 2008) and from Johnstown 1, Co. Meath (IID:117) where both hazel and oak charcoal were identified in one piece of slag, with the hazel probably deriving from kindling (Photos-Jones 2003d). There is potential, in the future, to identify the use of particular types of charcoal in different periods/places and possibly even associated with particular ironworking processes.

Peat

Very little evidence for the use of peat charcoal was identified on sites in the study, though this may be due to poor survival and difficulties in identification, in many cases it may not even be looked for (see discussion in Chapter 3). Historically, peat charcoal appears to have been used primarily in smithing (cf. Ross 1885-6, 409; Macadam 1886-87, 94-95; Evans 1948, 63; Crawford 1966; Feehan and O’Donovan 1996, 95-96) and the evidence gathered in this study, fragmentary as it is, does not contradict this impression.

At Reask, Co. Kerry (IID:176) peat charcoal was discovered all over the site in association with iron slag and other finds (Fanning 1981). It was also found in association with ironworking features in Structure D and Structure G, where it was used in combination with wood charcoal (Scott in Fanning 1981, 111). A peat stack excavated to the south of the site might indicate storage of peat in anticipation of its conversion to charcoal and a ‘fire pit’ located in Structure C may well have been used to produce charcoal. The pit was filled with peat charcoal and had evidence of a slate lining and possibly a slate covering (Fanning 1981, 92-93). It is very similar to a type of peat charcoal production pit described by Macadam (1886-87, 94-95) in the nineteenth century, located under the kitchen floor of old houses. One key piece of evidence for the use of peat charcoal in smithing on the site is the identification of both peat charcoal and wood charcoal within the makeup of a ‘furnace bottom’ (probably an SHC) found near Structure G (Fanning 1981, 118).

References to peat charcoal are rare from other sites in the study. At Clonmacnoise New-Graveyard (IID:061) ‘peaty charcoals’ were identified from shallow pits in the earliest levels.
(King 1993). Excavations for the installation of a water treatment plant, also at Clonmacnoise (IID:063), produced large, poorly consolidated SHCs with fine organic inclusions, which Young (2005h, 4) speculated might be the result of the use of peat charcoal during smithing on the site. The charcoal from Leacanabuaile, Co. Kerry (IID:137) was thought, after examination by a specialist, to have derived from peat, thought the identification was not certain (Ó'Riordáin and Foy 1941, 97). There was also evidence for the use of peat as a fuel, though not necessarily in charcoal form, at Larrybane, Co. Antrim (IID:136), though this was not necessarily associated with ironworking (Proudfoot and Wilson 1961-62, 106).

**Tools**

The tools of the smith are infrequently preserved in the archaeological record and are often indistinguishable from those of other craftspeople (see Chapter 2). Metal artefacts such as tongs, chisels, gouges, shears, files, callipers and punches are particularly rare finds and even where they are identified it is generally not possible to link them to smithing (Scott 1990). The study of iron tools requires systematic examination of iron assemblages using analytical techniques, particularly the bulk x-raying of material, and was beyond the scope of this study. For these reasons, this section concentrates on stone objects, which survive better and are more often identified and illustrated.

**Anvils**

Only one iron anvil dating to the period under study, from Garryduff 1, Co. Cork (IID:103), has been identified from Ireland (O'Kelly 1963; Scott 1990). The anvil was quite small and, considering the evidence for extensive non-ferrous metalworking from the site, may not necessarily have been used by a blacksmith (O'Kelly 1963). A large boulder excavated at Lowpark, Co. Mayo (IID:148) and used as an anvil base represents indirect evidence for the use of an iron anvil or anvils (Higgins 2008; Gillespie 2010). The stone was made of granite and had a stepped socket designed to hold the tang of an anvil, which was probably wrapped in a shock-absorbing organic material (Figs. 6.3 and 6.4). The boulder served as a permanent base into which iron anvils of varying sizes and types could be fixed depending on the work being undertaken (Higgins 2008). Unfortunately, no such anvil survived on the site; it may be that they were simply too valuable to be discarded, and probably too large to be easily lost.

Only a small number of stone anvils have been identified with certainty, though seventeen sites with possible examples can be pointed to (Table 6.3). The classic example comes from Clogher, Co. Tyrone (IID:055) and was illustrated by Scott (1990; Fig. 6.5). The use as an anvil is
inferred (quite strongly) through the proximity of a smithing hearth and the morphology of the rock, though there appears to have been no direct evidence in the form of scorching or adhering slag (Scott 1990, 167). A similar stone (Fig. 6.6) was identified during excavations at Rinnaraw, Co. Donegal (IID:177; Comber 2006b) by Tom Fanning. It is likely to have served some function, possibly as an anvil, during occupation of the site but unfortunately no evidence for this was recorded in the site records (Michelle Comber 2011 pers. comm.).

An anvil stone was reported by Cherubini (2005) from Lisleagh 1, Co. Cork (IID:141). It was embedded into the side of smithing hearth F129 and was capped by a layer of slag and burnt clay (Figs. 6.7 and 6.8). An angular stone fitted into one end of hearth F140 from Mackney, Co. Galway (IID:149) had slag adhering to it, pointing to its use in smithing (Delaney 2009a). Another potential anvil stone was identified at Kilmacthomas Area 16, Co. Waterford (IID:124). The stone lay in a large smithing hearth and had large stone fragments around it, possibly broken off from the main slab (Fig. 6.9). It also had shallow stakeholes on its northern and southern edges, possibly the remains of some kind of windbreak or shelter (Tierney and Elliott 2008, 104).

A number of anvils were recovered during excavations at Lowpark, Co. Mayo (IID:148). A large stone anvil in a pit, adjacent to hearth F133, was excavated in Ironworking Area 3 on the site (Figs. 6.10 and 6.11). The pit was probably dug to hold the anvil, which slipped at some point, moving from a level position towards the hearth (Gillespie 2010, 219). An area of vitrified clay around its southern and eastern edges probably resulted from the heating of the stone slab during hot working of iron (Fig. 6.11). Two similar stones were recovered from hearth F131 in Ironworking Area 1 and these are also likely to have functioned as anvils (Gillespie 2010, 211-213). Unusually, the stones were located in the centre of the hearth pit and it is not clear if this was their original position (Figs. 6.12).

Comber (2006a) identified a slightly different class of anvil stones from Cahircalla More, Co. Clare (IID:038). These were termed ‘mini-anvils’, had flat surfaces and were too big and heavy to be used as whetstones (Fig. 6.13). The frequent shallow scratches on their surfaces may indicate the cutting of metals with chisel and hammer, though it is not certain whether they were used in the smithing on site; they may relate to another craft or even multiple crafts (Comber 2006a). A similar anvil stone has been identified from excavations at Caherconnell, Co. Clare (Michelle Comber 2011 pers. comm.; Fig. 6.14). Described as an anvil fragment, it is substantially larger than the mini-anvils but with a similar rectangular cross-section. Caherconnell appears to have been occupied from the tenth century AD well into the Medieval
period (Comber and Hull 2010) and it is possible that Cahircalla More was occupied primarily in the thirteenth century (Taylor 2006a; Hull and Taylor 2007), perhaps indicating a late date for these smaller anvils.

**Bullauns, Mortars or Concave Stones**

Stones with concave surfaces, often termed bullauns or mortars, are common finds on sites with evidence for ironworking in Ireland (Dolan 2009), but there is very little understanding of the function and varying morphologies of these artefacts (cf. Corlett 2009). It is not yet clear if the varying sizes of these stones, from smaller portable examples to large earth-fast boulders and so-called bedrock mortars (Kelleher and O’Brien 2008), represent functional or chronological variance. What is clear is that some of these concave stones can be firmly associated with the smithing of iron during the early medieval period. It is not entirely clear what function they served and while those few tentatively associated with smelting (see Chapter 5) may have been used for the crushing, grinding and pounding of ore, charcoal and/or blooms, it may be that those associated with smithing were used in the consolidation of blooms or possibly as forms or moulds used to shape iron artefacts.

The most convincing evidence for the use of concave stones in the smithing process comes from Lowpark, Co. Mayo (IID:148). Two of the stones were found *in situ* in Ironworking Areas 2 and 4. The first (E338:258:140; Figs 6.15 and 6.16) was excavated in the centre of Area 2 adjacent to the hearth (Fig. 6.17). It had a hollowed out surface with a ‘possible metal fragment’ adhering to it and was classified as a possible saddle quern re-used in metalworking (Carroll and Quinn 2008, 388). The second stone was in two pieces (E338:424:303 and 304) embedded in the ground next to hearths F135 and F138, very close to the position of the tuyere (Figs. 6.18, 6.19 and 6.20). Made from granite, when complete it had an oval hollow at its centre which was quite rough, suggesting it was used for pounding rather than grinding (Carroll and Quinn 2008, 390).

These *in situ* examples are very important in demonstrating a link between the concave stones on the site and smithing. Other concave stones, including two sandstone examples (E338:240:266 and E338:512:274; Fig. 6.15) with smooth concavities thought to be used for grinding and a relatively large granite stone (E338:395:236) with a relatively uneven hollow, possibly connected to pounding, were found incorporated into the walls and fill of a souterrain (Gillespie 2008). Another small granite boulder (E338:467:262), mentioned above (Fig. 6.3), with an anvil socket on one side also had a concave basin on another face thought to have
been used subsequent to its use as an anvil base (Higgins 2008). The stone was found re-used as packing material in the construction of a palisade on the site in the early medieval period.

Very similar concave stones to some of those found at Lowpark have been found on other smithing sites. At Bofoennaun Crannog, Co. Mayo (IID:031) two stones (Figs. 6.21 and 6.22) with concave hollows were identified as mortars and one other slightly concave stone was identified as a possible saddle quern but is just as likely to relate to ironworking (Fig. 6.23). There is good evidence to suggest the site was primarily, if not exclusively, devoted to smithing (McDonnell in Keane 1995).

Other, possibly related, excavated stones with concave hollows from sites with definite and possible smithing evidence include a ‘mortar’ from Reask, Co. Kerry (IID:176; Fanning 1981, 136; Fig. 6.24), an un-illustrated saddle quern from Dromthacker, Co. Kerry (IID:088; Cleary 2008, 34), three mortars (one illustrated: Fig. 6.25) from Lagore, Co. Westmeath (IID:135; Hencken 1950, 175) and two mortars from Garranes, Co. Cork (IID:102; Ó'Ríordáín 1942, 110-111; Fig. 6.26). These smaller, so-called portable bullaun stones, which Corlett (2009, 32) suggests represent the majority of bullauns associated with church sites, seem very clearly, but probably not exclusively, associated with smithing.

Examples of bullauns associated with ironworking sites with indeterminate evidence for smithing from Gallen Priory, Co. Offaly (IID:101; Kendrick 1939, 5), Tullylish, Co. Down (IID:197; Ivens 1987), Cathedral Hill, Co. Armagh (IID:010; Gaskell-Brown and Harper 1984) and Nendrum, Co. Down (IID:163; Lawlor 1925), already discussed in Chapter 5, come from ambiguous contexts and it is not clear what their functions were. A number of other sites, with evidence for smithing, including St. Gobnet’s House, Ballyvourney, Co. Cork (IID:186; O’Kelly 1952), Toureen Peekaun, Co. Tipperary (IID:192) and Kilpatrick, Co. Westmeath (IID:126; Swan 1983, 244) have bullaun stones recorded in their vicinities with no evidence for associations with ironworking. Despite this, there is evidently a strong argument to be made that some bullauns/mortars served functions related to the production of iron.

This association may be restricted to smaller examples, and these ‘portable’ bullauns could potentially be seen as a sub-type or an entirely separate artefact type. There are few hints as to the actual use of concave stones associated with smithing, though it is reasonable to assume they were associated with the hammering, pounding or grinding of materials. The dished shape may have been useful as a form/anvil for shaping curved objects or as a container for preventing the loss of bloom fragments during consolidation (though the
evidence so far points to an association with secondary rather than primary smithing). Stones of similar shape and size were used in northern Nigeria in the 1940s for the shaping of hoes (Fagg 1952; Fig. 6.27). A passage from the (probably twelfth century) Life of St Kevin in which a smith is blinded by a chip from a stone he is grinding in a mortella (Plummer 1922, 241) may shed some light on the function of the stones. Price (1959, 181) translated mortella as ‘mortar’, suggesting it might refer to a concave stone or bullaun. The fact that a chip has flown off the stone, wielded by a smith, suggests hammering or pounding rather than grinding.

The concave stones discussed above all date to the early medieval period. The examples from Lowpark can be dated to Phase 3; the ironworking phase, with radiocarbon dates spanning cal. AD 559-967. Some of the stones from Lowpark are strikingly similar to a potential bullaun excavated by Glasgow University at The Carrick, Loch Lomond in Scotland. Here a boulder c. 50cm in maximum length and with multiple artificial depressions on its surface (Fig. 6.28) was found in association with two ironworking platforms and an enclosed cemetery, thought to be broadly contemporary, and dating in the range AD 690-900 (David Sneddon 2009 pers. comm.).

The best dated examples of ‘portable bullauns’ are those from Bofeenaun crannog, Co. Mayo, dated using dendrochronology to 804±9 AD (Keane 1995, 180). Only two sites in the study with associated bullauns were potentially dated earlier than the Early medieval period: Derrinsallagh 4, Co. Laois (IID:077) and Kiltera, Co. Waterford (IID:129). The example from Derrinsallagh 4 is not particularly convincing and may be natural (see Chapter 5) while that from Kiltera, described as “a stone with a smooth surface showing abrasions, such as would have been produced by pounding something upon it with a pestle” (MacAlister 1938, 5) is tentatively identified and from a very poorly dated context.

Hammers

Hammers are an essential part of a smith’s toolkit but they are rare finds on archaeological sites, particularly examples made of iron. Scott (1990, 23) identified no smith’s hammers in his review of Irish ironworking, though he did point to a number of setts (a type of chisel) that may have doubled as hammers from Cahercommaun, Co. Clare (IID:035), Lough Faughan, Co. Down (IID:146) and Lagore, Co. Westmeath (IID:135). One iron hammer is reported from Dooey, Co. Donegal (IID:082) but it is not illustrated and it is not clear to which phase of the site it belonged (Ó Riordáin and Rynne 1961, 62) and a small cobbler’s/jewellers hammer, probably not associated with smithing, was reported from Johnstown 1, Co. Meath (IID:117; Clarke 2004).
There is better, though still ambiguous, evidence for the use of stone hammers by smiths. The passage from the *Life of St Kevin* discussed above implies the use of a stone as either a hammer or grinding stone and a few potential examples of such an implement have survived. The most unusual is that from Knockcommane, Co. Limerick (IID:132; Fig. 6.29), an object described as a punch in the small finds report and found in a stratigraphically isolated pit (Scully 2007). It could also be described as a round hammer, similar to iron examples used until recently in Burkina Faso in Africa (cf. Roy 2008; Fig. 6.30). Another, coarse-grained, hammerstone was reported from topsoil on the site and can’t be associated with ironworking.

A crude hammerstone from Reask, Co. Kerry (IID:176) was identified and illustrated in the final report though its association with the ironworking on the site is not certain; a hone or rubbing stone reused as a hammerstone is also recorded from the site (Fanning 1981, 130). Six rounded stones identified as hammers were excavated at Leacanabuaile, Co. Kerry (IID:137), possibly associated with a stone mortar built into the wall of a house on the site (Ó'Riordáin and Foy 1941, 95). At Kilmacthomas Area 25 (IID:125) two large water-rolled pebbles from ironworking pit F112 with signs of use were seen as possible hammerstones, as were a number of other stones from the site (Tierney 2003, 251). Hammerstones are also reported from crannogs at Sroove, Co. Sligo (IID:184; Fredengren 2002, 238) and Bofeenaun, Co. Mayo (Lawless 1992, 19-20; Keane 1995, 176) while a pestle, possibly a stone hammer, was reported associated with the ‘mortar’ from Kiltera, Co. Waterford (IID:129) discussed above (MacAlister 1938, 5). A ‘pounding’ stone was also reported from an occupation layer at Carnmeen, Co. Down (IID:040; Masser and Dalland 2010).

It is very difficult to identify a hammerstone, which could be used in many different crafts, as a smith’s tool and none of the examples given above were unambiguously associated with smithing. However, there is every possibility that clearer examples from ironworking contexts will be identified in the future, where they are looked for.

**Sharpening Stones**

Sharpening stones include whetstones, grindstones, grooved stones and a variety of miscellaneous and re-used items. Practically any fine-grained stone, though usually sandstone (O’Connor 1991, 59-60), can be used to sharpen iron (or other metals) and it is not possible or productive to categorise them here. When compiling the database, numbers of whetstones for individual sites were recorded to test whether the quantity of sharpening stones on a site might relate to ironworking processes. For example, a large number of whetstones, as found at
Cahercommaun, Co. Clare (IID:035), might indicate knife production and a large number of grooved stones might indicate nail or pin sharpening. No such pattern could be identified and while some sites did have large numbers of sharpening stones, there appears to be no correlation between such numbers and the type or extent of the ironworking being carried out.

Rotary grind or whetstones have been seen as culturally Scandinavian and thought to date post ninth-century AD in Ireland (Sheehan et al. 2001, 105) but grindstones from Killickaweeny, Co. Kildare (IID:122) and Clonfad, Co. Westmeath (IID:058) have been identified as representing an Irish artefact type, associated with secondary ironworking, which continued into the Hiberno-Norse period in Dublin and elsewhere in northwest Europe (Riddler and Trzaska-Nartowski 2006; Trzaska-Nartowski and Riddler 2009).

The example from Killickaweeny came from a cistern containing iron slag and was sealed by a layer with two radiocarbon dates spanning 656-891 cal. AD (1260±60; Beta-185552) and 657-935 cal. AD (1250±60; Beta-185554) on alder charcoal (Walsh 2006). At least one complete rotary quernstone, from a spread dated to 775-972 cal. AD (1165±35; GrA-33803) and 689-891 cal. AD (1215±35; GrA-33804) on animal bone and two fragments, one dated 722-889 cal. AD (1206±23; UBA-8220) on mixed charcoal were identified from Clonfad (Stevens 2009).

A complete example and a fragment of a rotary grindstone were incorporated into the walls of souterrain 1 at Lowpark, Co. Mayo (IID:148) adjacent to Ironworking Area 2. The souterrain was dated by oak charcoal in its lower fill to 539-655 cal. AD (1460±40; Beta-231655) making it potentially even earlier than the Clonfad and Killickaweeny examples (Gillespie 2008; Higgins 2008; Gillespie 2010, 252). The association with the production of iron artefacts, presumably cutting tools, seems reasonably clear.

Smithing Hearths

While iron can be shaped to a limited extent using cold hammering, for most purposes a smithing hearth is required to raise the temperature of the iron between c. 700°C and c. 1200°C (Pleiner 2006, 123). The hearth is essentially a container for the fuel which is fed air through a bellows, often with the aid of a tuyere. Their design can vary widely from a simple pit in the ground to a complex raised forge built from a variety of materials (see Chapter 2; Pleiner 2000, 217-227; 2006, 123-131).
The identification of hearths can be problematic. Pit-hearths: rectangular or circular holes in the ground, are not very different from domestic hearths. Even an association with slag can be misleading without proper analysis; slag can easily be re-deposited in unrelated features. Similarly, a scorched circular pit containing slag and charcoal could, without further analysis, be interpreted as either a pit-hearth or the basal pit of a non-tapping furnace. Raised hearths are also difficult to identify as they rarely survive to any height (see Chapter 2). Nonetheless, slag associations (e.g. hammerscale distributions, SHCs) and other indicators such as smithing tools, scrap iron and blooms help in the identification of both hearth types.

While 59 smithing sites were identified, only 38 definite smithing hearths could be recognized from 25 sites (Table 6.4). This reflects the difficulties in identification as well as a conservative approach to interpretation; only features that could confidently be associated with smithing were included. A large number of ‘indeterminate’ features included in the Features Gazeteer (Appendix 5) could be either hearths or furnace bases.

Primary vs Secondary hearths

No attempt has been made here to differentiate between hearths used in primary and secondary smithing as the quality of the evidence does not support such distinctions without extensive analysis of many more slag assemblages. Only 15 sites had evidence for both smithing and smelting and of those, many had no, or only possible, evidence for hearths (Table 6.5). In many cases the identification of primary smithing on these sites is based largely on the coincidence of both smithing and smelting. However, it should be noted that three sites with clear evidence for primary smithing, Trumra 4, Co. Laois (IID:194), Rath na Ri, Co. Meath (IID:188) and Clonfad, Co. Westmeath (IID:058), had no evidence for smelting, suggesting primary smithing was not always carried out close to the furnace (see further discussion below).

An analysis of ironworking features along the route of the M4 motorway (Photos-Jones 2008a) proposed that rectangular and sub-rectangular hearths should be seen as bloom-smithing hearths associated with smelting in bowl furnaces (see also Photos-Jones 2003d; 2003a; 2007a). A re-assessment of the evidence from a number of sites in this road scheme, including Killickaweeny (IID:122; Photos-Jones 2004; Walsh 2006; 2008) and Johnstown 3 (IID:110; O’Hara 2002), Co. Kildare, Johnstown 1 (IID:117; Photos-Jones 2003d; Clarke 2004; Clarke and Carlin 2008; Clarke 2010), Hardwood 3 (IID:110; Photos-Jones 2003a; Murphy 2004b) and Rossan 6 (IID:179; Murphy 2004c; Photos-Jones 2007a), Co. Meath, and Kinnegad 2, Co. Westmeath (IID:130; Murphy 2003b; Photos-Jones 2003b), found no clear evidence for a
morphological distinction between primary and secondary smithing hearths (see Sites Gazeteer, Appendix 5 for further details).

**Morphology**

Hearths identified in the study are generally circular or sub-circular in plan, though rectangular and sub-rectangular examples are known, and others can be very irregular (Table 6.6). They have sides and bases of varying profile and it is not unusual for a hearth to have different shaped sides e.g. mainly sloping, with one steep edge. The bases of the hearths are also variable, with concave examples most common (11), flat bases next (8) and a substantial number of examples where it is not clear what type of base existed (14). The plans of hearths do not appear to follow any clear chronological pattern (Table 6.7).

**Length/Width**

Hearths in this study are generally larger than furnace pits (which were commonly between c. 0.30m and c. 0.50m; see Chapter 5), though there is a wide range of sizes identified for all hearth shapes (Fig. 6.31, Table 6.8). Differences in the size of hearths may relate to the size and shape of the objects being heated in them. Clearly, the forging of a long, thin sword would have required a larger hearth than one used to forge a smaller object such as a spearhead or knife. When the size of hearths is compared across sites of various dates there appears to be no chronological pattern, though very few examples date to the Iron Age (Table 6.9).

The largest hearth (F103) was reported from Johnstown 1, Co. Meath (IID:117; Photos-Jones 2003d). One end of the feature was scorched and an SHC was recorded in its fill, suggesting its use in smiting. At 1.85m in length, F103 is substantially longer than many other hearths in the study and there is a possibility that the SHC from its fill may be secondary. The next largest hearth, F132 from Lowpark, Co. Mayo (IID:148), which is sub-rectangular and measures 1.61m x 0.67m, has a far more secure identification based on its fill and its location within a dedicated ironworking structure (Gillespie 2010, 213-217; Fig. 6.32).

The smallest hearth included in this study (F163), measuring 0.30m in diameter, was identified within Structure D, a circular hut from Reask, Co. Kerry (IID:176; Fig. 6.33). It was part of a group of features originally interpreted as a mix of bowl furnaces and smiting hearths (Scott in Fanning 1981, 168; Fig. 6.34). Other small examples include a rectangular example from Ballycatteen, Co. Cork (IID:019) measuring 0.35m in length by 0.30m in width.
and another rectangular example, measuring 0.48m in length, found underlying a later stone-built cell on High Island, Co. Galway (IID:114).

All of these smaller examples have some measure of doubt over their identification and the smallest certain hearths are probably F136 and F137 from Lowpark, Co. Mayo (IID:148), which were in a group of ironworking features not associated with any structures (Figs. 6.35 and 6.36). Lowpark provides a good demonstration of the wide variation in the design, size and shape of smithing hearths, even within one site (Table 6.10). There appears to be no chronological aspect to the morphology of smithing hearths, though interpretation is made difficult due to the small number of directly dated hearths, many of which span similar periods (Fig. 6.37).

**Depth**

Depths were reported for 36 hearths, but issues with truncation and the fact that many hearths had irregular bases mean this is not a particularly useful indicator of the original character of smithing hearths. The deepest hearth identified is F138 from Lowpark, Co. Mayo (IID:148); it was located within a sunken ironworking structure (see below) securely dated to the early medieval period (Fig. 6.18 and 6.19). It is probably preserved to its original depth and provides a secure maximum depth for hearths in this study. The average reported depth is 0.14m, almost certainly an underestimate when truncation is taken into account.

**Lining**

The majority of smithing hearths identified had no surviving lining material but a significant minority had linings made of clay, stone or a combination of the two (Fig. 6.38). Evidence for the use of clay was found in a number of cases as well as some evidence for the re-lining/repair of hearths. The clearest example of the use of clay was from Lisanisk 2, Co. Monaghan (IID:139). Hearth F127 was originally interpreted as a bowl furnace with a clay plug used to close up an opening, through which slag and bloom could be cleared from the furnace (Photos-Jones et al. 2007). This plug, a sandy clay deposit (C275; Fig. 6.39), is far more likely to represent, as suggested by the excavator (Coughlan 2010, 21), a deposit intended to change the shape and size of a smithing hearth that was re-used multiple times. This interpretation is supported by the large range of SHCs recovered from the site (Photos-Jones et al. 2007).

Hearth F165 (Fig. 6.40), from Rath na Rí, Tara, Co. Meath (IID:188) has potential evidence for repair/relining using different grades of clay (Crew and Rehren 2002, 85-86), representing an Iron Age example of the practice. Clay lining was also identified at Killickaweeny, Co. Kildare
where hearth F109 has distinct bands of clay forming a lining as well as a sealing/dump deposit above a charcoal rich layer (Fig. 6.41). Baked clay lining is also reported from hearth F133 from Lowpark, Co. Mayo (IID:148; Gillespie 2008; 2010) but an interface layer of sand was also noted which lay between the clay and the sandy natural. It is not clear if this was a deposit or heat-affected natural (Figs. 6.10 and 6.11). The natural at Lisanisk 2, Co. Monaghan (IID:139; Coughlan 2010), a site with large-scale smithing similar to that at Lowpark, was also sandy and this may have been a factor in deciding where to construct hearths that were intended for prolonged use. At Coolcran, Co. Fermanagh (IID:066) one feature, F35, which appears to have been metallurgical but could not be firmly interpreted had a sand lining (Williams 1985a, 74). At Moynagh Lough, Co. Meath (IID:158) non-ferrous hearths (which had clear clay linings) were, apparently deliberately, filled with sand and small pebbles, possibly to protect them when not in use (Bradley 1993, 77-79).

**Stone Linings**

There was good evidence for the use of stone linings in hearths, though this was generally partial and often stone was used in conjunction with clay. Three hearths (F9, F96 and F111) from Ballycatteen, Co. Cork (IID:019; Ó'Ríordáin and Hartnett 1943), High Island, Co. Galway (IID:114; Scally 2000b; 2000a; 2001; 2004; Young 2006b) and Kilmacthomas Area 16, Co. Waterford (IID:124; Tierney and Elliott 2008) had stone linings with no evidence for clay. The first two hearths had only partial stone linings while the example from Kilmacthomas had a heat-affected flat stone in its fill that was either a basal lining or possibly an anvil stone.

Most hearths with evidence for stone lining also had evidence for the use of some kind of clay lining. At Lisanisk 2, Co. Monaghan (IID:139) one hearth (F126) had walls constructed of small planar stones and clay (Fig. 6.42; Coughlan 2010), reminiscent of hearths from Garryduff 1, Co. Cork (IID:103; O’Kelly 1963) and Clogher, Co. Tyrone (IID:055; Scott 1990; Warner 2000). These were both built above ground using similar materials (see discussion below). Another feature, F114 (Fig. 6.43) from Kilpatrick, Co. Westmeath (IID:126; Swan 1976; 1995), was of similar construction but was not clearly associated with smithing.

A very different design is evident from hearth F138 from Lowpark, Co. Mayo (IID:148; Gillespie 2008; 2010). This had one large flat stone slab which formed the vertical lining of one side of the hearth pit (Figs. 6.18 and 6.19). The slab had a notch in its upper surface that probably indicates the original tuyere location (see further discussion below) and it had a burnt clay lining. A steep, stable side to the pit would have produced a deep bed of charcoal. The very steep, regular edge formed by the clay packing in hearth F127 from Lisanisk 2, Co. Monaghan
(IID:139; Coughlan 2010) may be an attempt to achieve a similar effect (Fig. 6.15). At Clonfad, Co. Westmeath (IID:058) there was good evidence for the use of stones beneath the tuyere as protection against erosion of the hearth wall as the tuyere tip melted and reduced in length (Young 2009d).

Less direct evidence for lining of hearths (or the construction of superstructures) was found in the form of dumps of clay. At St. Gobnet’s House, Co. Cork (IID:186), a probable smithing site, lumps of whitish clay were found that had definitely been introduced to the site (O’Kelly 1952, 36). At Cahircalla More, Co. Clare (IID:038) patches of grey or white sandy clay were noted around the site, particularly near the probable smithy (Taylor 2006a, 7).

Superstructure

Raised smithing hearths, worked while standing, are the norm in modern smithies and there is iconographic evidence that similar raised hearths were in use in Europe in the Graeco-Roman world (Pleiner 2006, 123-124; see discussion in Chapter 2). Very limited evidence was identified for raised hearths in this study. It is not clear to what extent this is a problem of survival/identification rather than an actual representation of past realities.

The best example of a raised hearth (F27) came from Clogher, Co. Tyrone (IID:055; Warner 2000; 2009). It stood 0.50m above ground level and was constructed from clay and stone (Scott 1990, 167; Fig. 6.43). The hearth was adjacent to a large flat-topped boulder which would have served as an anvil (Fig. 6.5, 6.44 and 6.45). It may be that the height of the anvil stone influenced the decision to raise the hearth, making for an easier and more efficient working space. A second raised hearth from Garryduff 1, Co. Cork (IID:103) was c. 1.22m in diameter including the superstructure and survived to a height of 0.18m (O’Kelly 1963, 99-101). The central hollow measures about 30cm in diameter and 10cm deep. A blob of glass as well as crucibles associated with the feature suggest it was also used for non-ferrous metallurgy and glassworking. A dump of clay was located immediately to the south of the furnace. A single, iron anvil was recovered from Garryduff 1 (see above); this would have been mounted on a wooden block, possibly at a similar height to the hearth and was probably used for both ferrous and non-ferrous metalworking.

The early smithing hearth (F165) from Rath na Rí, Co. Meath (IID:188; Roche 1999; 2002) has no obvious superstructure but Crew and Rehren (2002, 92) suggested a double row of stakeholes on its southern edge may have supported a low clay superstructure. A possible stone setting was identified at Clonfad, Co. Westmeath (IID:058) within a potential smithy.
structure and could potentially be the footing of a raised stone hearth/chimney (Stevens 2009, 33; Fig. 6.47). Baked clay deposits in hearths from Lowpark, Co. Mayo (IID:148) were interpreted as part of superstructures by Wallace (2008) and Gillespie (2010, 228) but they do not extend around the hearths and are more likely to be tuyere settings (see further discussion below).

**Air Supply**

Hearths would have been blown by bellows and there is good evidence from this study that these were protected from the fire through the use of tuyeres. In some cases tuyeres were associated with stones or stone linings which served as protection for the hearth wall below the tuyere. This practice probably implies prolonged use of a hearth and it also gives an indication as to the positioning of bellows and tuyeres.

Tuyeres seem to have been used with open hearths and would have been angled down into the charcoal bed. Clear evidence for this can be seen in the tuyeres from Lisanisk 2, Co. Monaghan (IID:139; Fig. 6.48) which had angles of insertion between 45° and 60° as well as from Trumra 4, Co. Laois (IID:194) where the pad on which the tuyere sat suggested an angle of insertion of 10° -11° and Killickaweeny, Co. Kildare (IID:122) where the surviving tuyere suggested an angle of insertion of c. 30° (Photos-Jones 2004; Photos-Jones et al. 2007; Young 2008f). Good evidence for the placement of tuyeres was preserved in Ironworking Areas 2, 3 and 4 in Lowpark, Co. Mayo (IID:148; Gillespie 2008; Wallace 2008; Gillespie 2010).

In Area 2 a tuyere was found potentially *in situ* at the edge of the hearth pit (F132) and very close to a ‘saddle quern’, probably used as an anvil (Fig. 6.32). A clearly *in situ* tuyere was recovered in a similar position from Area 3 (Gillespie 2010, 223). It was located at the edge of hearth F133 close to a large, flat anvil stone and was associated with a clay lining or setting which was preserved only in the area of the tuyere and is visible in the feature section and mid-excavation photographs (Figs. 6.10 and 6.11). A similar localised area of baked clay can be seen in mid-excavation photographs of hearth F138 in Ironworking Area 4 and almost certainly represents the location of the tuyere, though none was recovered (Fig. 6.18). The heat-affected clay was located directly in front of and above an upright stone slab which formed the wall of the hearth below the tuyere and bellows. It was suggested by the excavator and specialist that this could indicate the remains of a superstructure (Wallace 2008; Gillespie 2010, 228). While this may be the case, it is better characterised as a setting or support for one of the large, tubular tuyeres of the type found on the site (see discussion below).
What is clear from these examples from Lowpark is that tuyeres, and thus bellows, were carefully placed, usually close to the anvil or working stone, probably to minimise the distance the hot iron had to be moved before it was worked. It also appears that the tuyeres were not moved around and the use of a stone lining in F138 suggests use of, or at least the intention to use, the hearth on multiple occasions.

**Tuyeres**

Tuyeres are relatively common finds on sites in the study (Table 6.11), though rarely in great numbers and no complete examples have been recovered. Their poor survival appears to be due in large part to their method of construction. They are formed from unfired clay and consequently generally only the tip nearest the heat of the fire is vitrified/baked sufficiently to survive. One tuyere from Killickaweeny 1, Co. Kildare (IID:122) had striations on the interior of its bore, possibly related to the production process (cf. Photos-Jones 2004).

Evidence from this study suggests tuyeres can be split into two types: large and small, with the smaller category associated exclusively with non-ferrous industries. The larger category is clearly associated with iron-smithing but not smelting. This represents a significant improvement of previous understandings of tuyere use, providing a much clearer understanding of the technology of both ferrous and non-ferrous industries and providing a new archaeological indicator (large tuyeres) of iron-smithing activity, at least on early medieval sites.

**Classification**

Scott (1990, 162-167) classified Irish tuyeres into three types. The first included small clay tubes with apertures between 1cm and 1.5cm in diameter and walls measuring 2-3cm in thickness (see Fig. 6.49, a-d). The second type was larger, including examples with apertures around 3cm in diameter, wall thicknesses between 3cm and 5cm and overall diameters between 13cm and 15cm (see Fig. 6.49, e-g). Finally, he identified a series of perforated clay discs, flat or slightly convex in section, with apertures c. 1-3cm in diameter, wall thicknesses between 1cm and 4cm and overall diameters of between 12cm and 16cm (see Fig. 6.49, h-j).

Later surveys by Pleiner (2000, 205-212; 2006, 132-133) of European tuyeres identified four basic types (Fig. 6.50). Tubular tuyeres were cylindrical in shape, often with the end receiving the bellows nozzle splayed out in the form of a trumpet. Concial tuyeres were short and defined by their shape and appear to have been restricted in their geographic spread to parts of France and Switzerland (Pleiner 2000, 208). Block tuyeres were generally used in furnace
arches and included types resembling perforated bricks as well as semi-circular or ogival blocks with bores in their upper bodies (Fig. 6.50). His final category: disc tuyeres appear to be based primarily on Scott’s classification of ‘perforated clay discs’ and the examples given are almost all from Ireland (Pleiner 2000, 212). Pleiner discussed tuyeres primarily in the context of smelting but identical designs were also used in smithing (Pleiner 2000, 206, 208).

Tuyeres were not the only possible solution for bellows protection when smithing. Clay or stone shields could be used, in a similar way to that suggested by Scott for his clay discs, with perforations for the insertion of either a tuyere or the bellows nozzle directly (Pleiner 2006, 132; Fig. 6.51). The use of tuyeres vs shields with blowholes may have influenced the way slag formed within the smithing hearth. The ‘pro-tuyere tongues’ identified by Young (2009d; see Chapter 2) would not have formed where shields were used (Fig. 6.52). In some respects these solutions are similar to Pleiner’s semi-circular or ogival block tuyeres (Fig. 6.50).

Since Scott’s (1990, 162-167) survey of Irish tuyeres related to ironworking a significant number of well-preserved tuyere fragments have been excavated. A re-assessment based on this new evidence supports the broad differentiation between small and large tuyeres, though it is likely that ‘perforated discs’ are in fact the preserved ends of tubular tuyeres.

Large Tuyeres
Numerous large tuyere fragments with complete diameters and clearly defined blowholes have recently been identified from Lisanisk 2, Co. Monaghan (IID:139; Fig. 6.48; Photos-Jones et al. 2007; Coughlan 2010), Lowpark, Co. Mayo (IID:148; Fig. 6.53; Gillespie 2008; Wallace 2008; Gillespie 2010) and Killickaweeny, Co. Kildare (IID:122; Fig. 6.54; Photos-Jones 2004; Walsh 2006; 2008). These examples are cylindrical in shape, with conical bores (see Fig. 6.55), vitrification on their faces and, very often, small hoods over their apertures that show the angle at which air was being blown while they were in use. Many of them also exhibit slight ‘slag beards’, or flattened edges, where they were in contact with the ground surface/hearth edge, though their original (as constructed) circular cross-sections can be seen on surviving rear cross-sections (e.g. Fig. 6.48). A similar design is also represented by the near complete tuyeres from earlier excavations at Ballyvollen, Co. Antrim (IID:028; Fig. 6.56; Williams 1985b).

These tuyeres had relatively uniform size ranges, between c. 10cm and 15cm in diameter with apertures on their vitrified faces between 1.5cm and 3cm (Table 6.12). Fragmentary examples from other sites also conform broadly to this type. At Lisleagh 1, Co. Cork (IID:141; Monk 1988; 1995; Cherubini 2005) substantial fragments of three tuyeres (Fig. 6.57) were identified.
Tuyere A gave an estimated diameter of 18cm while Tuyere C displayed a well preserved bore narrowing from 6.5cm to 3cm at its tip (Cherubini 2005). A similar tuyere fragment, with an estimated 13cm diameter and a conical bore, is recorded from Waterunder, Co. Louth (IID:201), though it is referred to as a blowhole (Scully 2010; Fig. 6.58). The tuyeres from Cathedral Hill, Armagh (IID:010) were tentatively interpreted in the original report as ‘tubular’, ‘circular’ or as blowpipes (Gaskell-Brown and Harper 1984, 149-150). The largest illustrated example (No. 156, Fig. 6.59) fits happily into the corpus of ‘large tuyeres’ discussed here, with an estimated diameter of c. 10cm and an aperture measuring c. 3cm at its smallest point. Other tuyeres from the site belong to the smaller category of tuyeres (see below).

Fragments of tuyeres from Clonfad, Co. Westmeath (IID:058) had typical diameters of c. 14cm with c. 2.6cm apertures and a photograph of one tuyere suggests they had a conical bore (Fig. 6.60; Young 2009d). One very large tuyere from the site, measuring c. 20cm in diameter, dates to the later medieval period. This is reminiscent of other very large tuyeres from Ballykilmore 6, Co. Westmeath (IID:025), similar to the earlier ‘large tuyeres’, but with diameters between 20cm and 30cm and dating to the 16th-18th centuries (Young 2009a).

The late examples from Ballykilmore 6 were also associated with baked clay supporting blocks, arranged on either side of the large tuyeres to keep them in place. One smaller tuyere from the site with a tapering bore and a 14cm diameter was thought to date to the early medieval period. Relatively large tuyeres, measuring 18cm in diameter and firmly dated to the second half of the early medieval period, have been identified at Toureen Peekaun, Co. Tipperary (IID:192), approaching the upper size limit of known early medieval Tuyeres; evidence was also identified for pads of clay used to hold the tuyeres in place (Young 2010).

**Small Tuyeres**

The smaller category of tuyeres had straight bores around 1cm thick and thin walls. They would have delivered smaller amounts of air and were probably meant for use at lower temperatures than the ‘large tuyeres’ discussed above. Scott (1990) pointed to examples from Cathedral Hill, Armagh (IID:010; Gaskell-Brown and Harper 1984), Garranes, Co. Cork (IID:102; Ó’Riordáin 1942) and Lagore, Co. Westmeath (IID:135; Hencken 1950), all of which were fragmentary (Fig. 6.49 a-d). The example from Garranes (Fig. 6.49, c) had a diameter of 5cm and a bore of 1cm, almost exactly the same measurements as the example from Cathedral Hill pointed out by Scott (1990; Fig. 6.49, 158). Other fragmentary pieces of tuyere from Cathedral Hill (particularly no. 161, Fig. 6.59) probably also belong to the same category of ‘small tuyeres’.
All of these small tuyeres were found on sites with extensive evidence for non-ferrous pyrotechnical industries. The example from Lagore was found alongside evidence for glass casting (Hencken 1950, 126). The exact context of the example from Garranes is not clear from the published report but the site had clear evidence for a non-ferrous workshop with only limited ironworking activity (Ó’Riordáin 1942) and one example from Cathedral Hill was found in association with a crucible and a heating tray indicative of non-ferrous metallurgy (Gaskell-Brown and Harper 1984). Baked clay ‘nozzles’ were also identified at Moynagh Lough, Co. Meath (IID:158) directly associated with bronze-casting, though no information is available on their morphology (Bradley 1991b).

**Perforated Discs**

Scott (1990) identified examples of ‘perforated clay discs’ (Fig. 6.49 h-j) from St. Gobnet’s House (IID:186; Fig. 6.61, 1-3), Garryduff 1 (IID:103; Fig. 6.62) and Lisleigh 1 (IID:141; Fig. 6.57), all in Co. Cork and from Cathedral Hill, Armagh (IID010; Fig. 6.59) and Reask, Co. Kerry (IID:176; Fig. 6.63). These examples are far less convincing as a type and instead appear to be fragmentary or less-well preserved examples of the large tuyeres discussed above. For instance, the example from Cathedral Hill (Fig. 6.59, 164) is different from that accepted as a ‘large tuyere’ (Fig. 6.59, 156) only in that it has less of its fabric preserved. Its diameter is similar, as is the size of its aperture and there is even a hint of a conical bore. Similarly, the examples from Reask (Fig. 6.63) are very likely to represent the surviving front ends of longer tuyeres rather than thin discs of clay. Indeed Fanning (1981, 118) notes they ‘compare well’ with the rather more substantial, but undated, tuyere from Carrigmuirish Cave (illustrated in O’Kelly 1963; Fig. 6.64).

Scott’s (1990, 167) suggested function for these clay discs, as upright shields for smithing hearths (depicted in Fig. 6.51), seems overly complex and actually quite impractical. The small size of the discs would have provided little heat protection and would not have been very useful for containing the charcoal bed. It is far more likely that they represent the fragmentary remains of large tuyeres.

**Association with smithing**

For a long time, based on Scott’s (1990, 162-167) analysis, tuyeres have been associated with both smelting in bowl furnaces and smithing in similar bowl-shaped hearths. More recently, Young (2009d) has argued that ceramic tuyeres were an integral part of the early medieval smithing (and not smelting) process in Ireland, contributing silica to the slag and leading to the
very large SHCs identified from sites such as Clonfad, Co. Westmeath (IID:058). There is strong evidence from this study supporting the exclusive association of ‘large tuyeres’ with iron smithing. Sites with evidence for tuyeres very frequently have clear evidence for smithing (Table 6.11). Many have no evidence for smelting and, perhaps most convincingly, no single-function smelting site (i.e. without any evidence for smithing) has produced evidence for tuyeres, though these are admittedly small in number in the early medieval period (see Chapter 8).

The clearest examples of the association between smithing and tuyeres come from Clonfad, Co. Westmeath (IID:058), Lowpark, Co. Mayo (IID:148) and Lisanisk 2, Co. Monaghan (IID:139). Clonfad was a specialist smelting site engaged in the production of brazed iron handbells and probably other iron items; it had very little evidence for smelting activity (Stevens 2009; Young 2009d). Lowpark also appears to have been a smithing site, probably in the context of domestic occupation and with no evidence for smelting on site (Anguilano 2008; Wallace 2008; Gillespie 2010). Lisanisk 2 had the largest number of intact tuyeres of any site in the study and has been interpreted here as a specialist smithing site contra Photos-Jones et al (2007).

Only one site in the study, Carrigoran, Co. Clare (IID:044), produced a tuyere associated with a possible furnace. Tuyere fragments were recovered from the upper fills of a pit (F18) tentatively identified as a smelting furnace. However, the specialist analysis of the site suggested there was a high degree of ambiguity in the residues from F18 and, while it was definitely metallurgical, its association with smelting was not certain (Young 2005a).

**Date**

The majority of tuyeres identified on sites in the study dated to the early medieval period but a very small number of sites produced tuyeres with earlier dates (see Table 6.13). It is not clear, due to the small number of examples, if Iron Age tuyeres were similar in form and construction to later examples. Their scarcity may be related to the general scarcity of smithing sites from the period (see Table 6.14).

One site, Trumra 4, Co. Laois (IID:194) produced an erroneous Early Bronze Age date from a pit which also contained a fragment of a ‘large tuyere’ (Young 2008f; O’Neill and Kane 2009). Other fragments where found elsewhere on the site and one other radiocarbon date, spanning 396-547 cal. AD (1595±35; SUERC-18526), suggests the tuyere and other ironworking material from the site actually represent an early medieval technology. Only two sites produced evidence for Iron Age tuyeres. At Lisnagar Demesne 1, Co. Cork (IID:143) an ‘incomplete tuyere
of the tubular variety’ (Murphy 2006b, 53) was reported. Unfortunately, it was not illustrated or described in any further detail. A tuyere fragment from Waterunder, Co. Louth (IID:201), discussed above, came from a dump context within a pit (McQuade 2006; Scully 2010). A nearby furnace (F170) produced a date on alder charcoal of 165 cal. BC to 54 cal. AD (2034±38; Wk-17456; McQuade 2005; 2006), providing a possible, but indirect, date for the tuyere.

Slag

The diagnostic slag types associated with smithing have been discussed in detail in Chapter 2 and smithing slag from sites in this study conformed to this technological framework. Slag from smithing sites in the study was not directly analysed, with the exception of an assemblage from Mackney, Co. Galway (IID:149; Appendix 1). An in-depth characterisation and comparison of slag types, sizes, morphologies etc was beyond the scope of this study.

The primary indicators of smithing on most sites were smithing hearth cakes (SHCs). These can and were referred to using a variety of terms and it is likely that so-called furnace bottoms reported from many sites were in fact SHCs. Overall, a substantial number of sites (51) had reported furnace bottoms, plano-convex bottoms or other similar slag types. Micro-residues or hammerscale, indicative of smithing, were also reported from a significant number (25) of sites. None of the sites had systematic hammerscale surveys, which can identify working spaces, anvil location etc (e.g. Sim 1998; Paynter 2007b; Veldhuijzen and Rehren 2007; Jouttijärvi 2009), carried out.

Smithing Pan

Smithing pans are concretions of smithing debris, usually a mixture of hammerscale, slag, stones, charcoal and soil formed near the anvil in an area where repeated smithing has taken place (Crew 1996; Bayley et al. 2001, 14). Very few examples of this type of smithing residue have been published from sites in Ireland, though a large, probably medieval, example found during field survey near a motte in Clonard, County Meath (Fig. 6.65) was published by Kenny (2007a, 63-64). A number of examples were reported from sites in this study.

A smithing pan (Fig. 6.66), from a secondary context, at Baronstown 1, Co. Meath (IID:030) weighed 16.04kg and incorporated a large stone (Wallace 2009a). A slightly larger ‘concretion’ was identified from pit C7 in Ironworking Area 1, Lowpark, Co. Mayo (IID:148) adjacent to smithing hearth F131 (Fig. 6.67; Wallace 2008); it is not clear if this was in situ but it is likely it formed within the general vicinity of Ironworking Area 1. At Carnmeen, Co. Down (IID:040)
fragments of smithing pan from a pit on the periphery of the excavation are likely to have been dumped (Cruickshanks and McLaren 2009). Fragmented iron pan was also identified from Ballykilmore 6, Co. Westmeath (IID:025; Young 2006d), Ballydavis 2, Co. Laois (IID:021; Young 2005d) and Kilmacthomas Area 16 (IID:124; Tierney and Elliott 2008, 101).

Possible unidentified smithing pans can be pointed to from a number of sites. At Kilpatrick, Co. Westmeath (IID:126) a large amount of ‘iron spalls’ within F113, a forging area or hearth may represent a fragmented smithing pan (Swan 1995, 9). Similarly, at Lisanisk 2, Co. Monaghan (IID:139) a heavily orange-stained area noted by the excavator in Industrial Area 1 (Coughlan 2010, 20) and identified by the specialist as having a high magnetic content (Photos-Jones et al. 2007), might be the remains of a smithing floor or pan. At Lagore, Co. Westmeath (IID:135), Hencken (1950, 233) referred to 'ironworking floors' that could possibly have been smithing pans.

**Bloom and Bar**

Unconsolidated or raw blooms taken directly from smelting furnaces (discussed in Chapter 5) require consolidation to remove unwanted slag and weld together separately formed pieces of iron (see detailed discussion in Chapter 2). The production of consolidated blooms is termed primary smithing and is often associated with smelting sites (Pleiner 2000, 215-229). Surprisingly, primary smithing was not confined to smelting sites in this study.

Three sites, Trumra 4, Co. Laois (IID:194), Rath na Ri, Co. Meath (IID:188) and Clonfad, Co. Westmeath (IID:058), had little or no evidence for smelting but had evidence for primary smithing (Crew and Rehren 2002; Young 2005b; 2008f). This indicates that in some cases at least unconsolidated blooms were transported from the smelting location to a different area for smithing. Indirect evidence for this practice can also be seen in the lack of evidence for smithing (of any kind) from many smelting sites (Table 6.15).

In the British Iron Age, consolidated iron was often shaped into bar iron or ‘currency bars’, and this may have been the state in which iron as a raw material was transported, for trade and other reasons (cf. Hingley 1990; Crew 1995b). There is no evidence from sites in this study for the production of specific forms of consolidated iron for trade/exchange. Nevertheless, the frequent separation of smelting and smithing sites in both the Iron Age and early medieval periods in Ireland (see Chapters 7 and 8) suggests iron must have been transported from one to the other in some, perhaps not standardised, form.
A small fragment of possible consolidated bloom was excavated from the early medieval phase at Raystown, Co. Meath (IID:175; Fig. 6.68). The fragment was enveloped in slag/corrosion and it is not clear to what extent this resulted from post-deposition processes (cf. Photos-Jones 2009). Three large fragments of slag from Kilrussane, Co. Cork (IID:127) were thought to be potential blooms although they were not sectioned so the interpretation cannot be confirmed (Photos-Jones 2003c). Proudfoot (in Collins 1955, 73-75) mentioned ‘iron blooms’ from Lough Faughan Crannog, Co. Down (IID:146) that awaited analysis. Scott (1990) mentioned two consolidated blooms from the site, though a question mark beside the entry for the blooms in his catalogue may imply some uncertainty about either their quantity or identification.

Scott (1990, 162) also recorded consolidated blooms from two sites excluded from the study due to poor dating: Carrigmuirish and Brother’s Cave, both in county Waterford (see also Ussher 1885-86; Forsayeth 1931; Tylecote 1986, 191-193; Dowd and Corlett 2002). He also referred to an iron ingot from Lissue, Co. Antrim (IID:145), possibly the heavy iron bar referred to by Tylecote (1986, 188), and reported in one of the published site reports (Bersu 1947, 50). Probable ingot or bar fragments were also identified by Ó’Riordáin (1942, 107) from Garranes, Co. Cork (IID:102). These consisted of fragments of thick iron bar (Fig. 6.69, No. 446) and a cuboid piece of iron (Fig. 6.69, No.441).

The scarcity of finds of identifiable stock iron in whatever form is surprising but is probably due more to problems with corrosion, identification and a lack of study than a real scarcity in the archaeological record. A closer inspection of non-descript iron finds from future and past excavations would probably yield many examples of iron in a state ready to be worked into usable artefacts.

**Associated Features and Structures**

Basic smithing requires little more than a hearth, a hammer and an anvil but evidence from sites in this study suggest these were sometimes, particularly in the early medieval period, housed within dedicated structures. Secondary smithing is often carried out under shelter, as protection from weather but also to create low-light conditions conducive to observing colour changes in the metal and thus judging temperature (Pleiner 2006, 53). Early medieval texts imply the existence of substantial dedicated smithing structures (prone to fire damage) but an eight-century tract which implies a danger to animals close to the hearth may indicate more open and less substantial structures were in use (Scott 1983a, 61-62; 1990, 191-197).
Sites in this study provided very little evidence for dedicated forge structures prior to the early medieval period. However, there is very good evidence from the fifth or sixth centuries on for both specialist smithing structures as well as a variety of rectangular and circular buildings which may have had multiple purposes. At the same time, there is also good evidence for smithing being carried out without any shelter, sometimes in isolated locations, possibly relating to more ad-hoc or temporary activity.

**Bronze Age/Iron Age**

Very few sites in this study had evidence for smithing prior to the early medieval period (Table 6.14), and there was little evidence for structures from those that did. Only four sites – Rathgall, Co. Wicklow (IID:171; Raftery 1970; Raftery 1976b; Rehren 2007), Altanagh, Co. Tyrone (IID:005; Williams 1986), Chapelbride 1 (IID:051; Danaher and Ginn 2008) and Rath na Ri (IID:188; Roche 1999; Crew and Rehren 2002; Roche 2002) in Co. Meath – had clear evidence for smithing hearths potentially dating to the Iron Age, though the ironworking from Altanagh is likely to date later and is dealt with below.

The smithing hearth from Rath na Ri was surrounded by numerous stakeholes and a number of postholes highly suggestive of some kind of structure, but it was not possible to make out any clear plan (Roche 2002. 29-39; Fig. 6.70). Evidence for smithing from Ballydavis 2, Co. Laois (IID:021) may have been associated with two possible post-built structures with porches just outside the main enclosure (Young 2005d). However, the site is unpublished and very little further information is available.

At Harlockstown, Co. Meath (IID:111) a large number of features were dated to an Iron Age phase including a possible house structure and a sunken-floored feature (Fig. 6.71) but no structures could be clearly connected to smithing activities (O’Connor 2008). A possible rectangular structure was excavated at Gransha, Co. Derry (IID:109). It would have measured 5.39m in length and a group of stakeholes at the edge of the structure may have formed windbreaks, possibly on an open side of the structure (Chapple 2010a; Fig. 6.72). Unfortunately, the slag from the site was not analysed so it is not clear if the structure related to smelting or smithing.

The smithing hearths from Chapelbride 1, Co. Meath (IID:051; Danaher and Ginn 2008) and Rathgall, Co. Wicklow (IID:171; Fig. 6.73) were not associated with any structures. Similarly, no evidence for structures was found at other Iron Age smithing sites including Cherryville Site 12,

Early Medieval

Sunken Forges

A passage in the *Betha Brennain*, possibly written c. 800 AD (O'Sullivan 2009, 85) describes St. Brendan and his companions chancing upon an Isle of Smiths full of ‘thigibh amhail cherdcadaiph’ translated by Scott (1990, 190) as ‘houses like forges’. The implication is that the forge or smithy where the smith worked at his anvil had a distinctive form in the early medieval period, one that was identifiable from a distance. The archaeological record suggests that this was indeed the case, with a small number of sites producing evidence for distinctive rectangular ‘sunken forges’.

*Lowpark*

Lowpark, in Co. Mayo (IID:148) had extensive evidence for prolonged specialist smithing activity in a number of separate ironworking areas (cf. Anguilano 2008; Gillespie 2008; Wallace 2008; Gillespie 2010). Three of these (Areas 2-4) were sunken, with two preserving associated structural evidence (Areas 2 and 4). Another (Area 1) had evidence for a non-sunken, post-built sub-circular structure, possibly built against the inner edge of a palisade fence (Figs. 6.12 and 6.74).

The sunken forge from Area 4, which was rectangular in plan and measured 5.2m x 3.4m at ground level and 4.5m x 3m at its base, had good evidence for its method of construction (Figs. 6.18 and 6.19). A slot trench surviving on two sides and a number of irregularly spaced postholes indicate a plank-built semi-sunken building; there was no evidence for how it would have been roofed (see Fig. 6.75 for a conjectural reconstruction of the building).

The forge in Area 2 was slightly bigger, measuring 3.8m x 2.6m at ground level and 2m x 1.65m at its base. Five structural posts remained around its perimeter, four of which may have formed a rectangular porch area on its north-eastern side (Figs. 6.17 and 6.32). The north-western wall of the sunken area was formed by the wall of an adjacent souterrain (Gillespie 2008; 2010). A further sunken area in Ironworking Area 3 contained a rectangular pit measuring 6 x 4.1m but had no surviving structural remains (Figs. 6.10 and 6.11). Considering the evidence for the other sunken forges on the site it seems reasonable to assume that this constitutes a third example.
The post-built structure in Area 1 along with a number of miscellaneous pits and hearths scattered in and around the main ironworking areas suggest that other types of structures may also have been used for smithing on the site. The ironworking at Lowpark was dated very broadly by a number of radiocarbon dates to somewhere between cal A.D. 559-967 (Fig. 6.76; Gillespie 2010). However, even considering the relatively large amount of slag generated on the site (1371.75 kg), the smithing need not represent a particularly long period of ironworking, beyond one generation, most likely sometime in the seventh, eighth or ninth centuries AD.

**Lisanisk 2**

The sunken forges from Lowpark are paralleled by two ‘Industrial Areas’ excavated within the bivallate enclosure at Lisanisk 2, Co. Monaghan (IID:139; cf. Photos-Jones et al. 2007; Coughlan 2010). The ironworking from Lisanisk 2 was potentially contemporaneous with the smithing at Lowpark (Fig. 6.76) and produced a similarly substantial (850kg) slag assemblage. The parallels, in the scale of the activity on the site and the construction of the forge areas, with Lowpark are striking.

Industrial Area 1 was located to the west of the site in a hollow that had been re-cut into the silted-up inner ditch (Fig. 6.77). The central part of the hollow was sub-rectangular in shape and 1.23m in maximum depth; two shallower hollows, apparently used as dumps, were cut to the north and south of the central sunken area. Overall, the hollow measured 10.8m in length but the central part measured c. 4.8m in length by c. 3.35m in width (based on the plan: Fig. 6.77), broadly similar to the sunken forges from Lowpark.

There was no evidence for structural post-holes, though a number of stakeholes were found surrounding a shallow linear slot to the north of hearth F127. The possible remains of a burnt wooden beam were found in the slot but it is not clear what function the features served. They may relate to a substantial bellows structure, some other forge furniture, or possibly the roofing of the hollow. A similar slot to the south of the hearth was seen as the impression left by a heavy piece of timber, possibly the base of an anvil (Coughlan 2010, 20).

One interpretation suggests the roof of the hollow rested on banks to either side, supported by a number of small posts (Niall Roycroft pers. comm.; Fig. 6.78). It seems more likely, given the similarity between this hollow and those from Lowpark, particularly in terms of the size, the well defined edges and the hearth pit, that the central part of the hollow may have been plank-lined and roofed in a similar manner.
Industrial Area 2 at Lisanisk 2 was thought to post-date Area 1, with spoil from its excavation having been dumped in Industrial Area 1, indicating continuous use (Coughlan 2010). Industrial Area 2 was also re-cut into the inner enclosure ditch, though it was not as clearly defined as Area 1, nor as deep (Fig. 6.76). The hearth (F126) was located adjacent to a low drystone kerb/wall built at an angle along the partially filled ditch; another small wall to the west acted as a barrier across the ditch. It is not clear how these walls relate to the hearth and if they formed part of any structure or were certainly contemporary. The location of the hearth adjacent to a straight stone edge is reminiscent of the arrangement in Iron working Area 2 at Lowpark (Fig. 6.17).

Other Sites
A number of sites in this study had evidence for smithing activity located within sunken hollows, often in silted-up ditches. None of these have clear evidence for having been roofed but the location of smithing within such sunken areas parallels the sunken forges at Lowpark and Lisanisk 2. The ‘sunken’ nature of these sites appears to be an important element of early medieval forge buildings, a design element also seen in many Irish smelting sites (see Chapter 5).

The earliest example comes from Clogher, Co. Tyrone (IID:055) where one smithing hearth (F27) and one, or possibly two, other ironworking features were found in a hollow in the ditch of the second hillfort (Scott 1990, 160; Warner 2000). It is not possible to tell from the plan of the ironworking to what extent the hollows might have resembled those from Lowpark and Lisanisk 2 (see Fig. 6.45) and the site awaits further publication.

Ironworking Area 1 at Johnstown 1, Co. Meath (IID:117), dated between the seventh and tenth centuries AD (Clarke and Carlin 2008, 73), was located at the confluence of three ditches. It consisted of a spread with maximum dimensions of 6.2m x 3.2m which had a number of features cut through it, including an ironworking feature (F99; Figs. 6.80 and 6.81). It is not clear if the area was sunken to any great depth, though the spread was between 0.10m and 0.90m in thickness. The same phase of ironworking included Ironworking Area 2 (Fig. 6.80) and a dump of slag weighing 422kg, similar in scale to the debris recovered from Lowpark and Lisanisk 2.

A sunken feature at Kinnegad 2, Co. Westmeath (IID:130; Murphy 2003b) has already been discussed in relation to sunken smelting furnaces (see Chapter 5) and is similar in some ways
to the sunken forges discussed here. It is not totally clear if it relates to smelting or smithing, though its similarity to the sunken smelting furnace from Caherweelder 7, Co. Galway (IID:037; Hegarty 2010), probably suggests the former.

The twin smelting furnaces from Knockbrack, Co. Kerry (IID:131) were also discussed in Chapter 5 (Hull and Taylor 2006; Fig. 5.8). They were part of a sunken complex, the west end of which may have been used for smithing; this separate and stone-lined area was very disturbed by tree roots and no evidence for a hearth was found, though an incised stone object (Fig. 6.82), probably used for sharpening, is suggestive of the finishing of iron tools. It is not clear if the sunken area was roofed.

Hollows were also identified at Dunmisk, Co. Tyrone (IID094) and Tullylish, Co. Down (IID:197) that may possibly relate to smithing, though a lack of slag analysis means smithing cannot certainly be identified. At Tullylish substantial postholes suggest a possible structure in a sunken industrial area located in a silted-up ditch (Ivens 1987, 61). A broad gully used exclusively for ironworking at Dunmisk and containing a number of postholes was paralleled with the sunken area at Tullylish by the excavator (Ivens 1989, 20).

**Circular Structures**

While smithing seems to have been undertaken in specialised sunken buildings/areas, it was also commonly practiced in more conventional circular buildings. Circular buildings in early medieval Ireland were associated primarily with domestic activities, being gradually replaced by rectangular houses after c. 800 AD (Lynn 1978; 1991a; 1994; O'Sullivan 2008; O'Sullivan et al. 2010a, 18-51; O'Sullivan and Nicholl 2010). In terms of the large number of circular buildings known from early medieval Ireland (cf. O'Sullivan et al. 2010b), a relatively small number housed smithing activity. This activity was small-scale and, in some cases at least, temporary. It is possible that the buildings were used as smithies for short periods or were used as such at the end of their domestic lives. There also seems to be an association between ecclesiastical circular structures and smithing, possibly indicating a different understanding of such spaces on ecclesiastical sites.

At Cahircalla More, Co. Clare (IID:038) clear evidence for small-scale smithing was associated with a large enclosure, within which were the foundations of a circular structure which hosted small-scale smithing (Taylor 2006a; Fig. 6.83). Slag from the site was mostly found dumped in the enclosing ditch, with slag fragments and hammerscale indicating activity within the circular
structure (Keys 2006). This small quantity of slag from the site (16.6kg) suggests the building was only used as a smithy for a very short time.

Evidence for smithing activity on a ringfort at Dunbell 5, Co. Kilkenny (IID:092) is uncertain but a horseshoe shaped structure found within the enclosure had a floor ‘strewn with slag’ and was interpreted as a workshop (Cassidy 1991a, 20). The structure was defined by a foundation gully measuring c. 2.5m in diameter with one or two postholes (Cassidy 1991b, 4). There was no direct evidence for burning or a hearth making the interpretation as a workshop tentative but it is possible that the hearth was raised, leaving no in situ remains.

At Reask, an ecclesiastical site in Co. Kerry (IID:176; Fanning 1981), smithing was carried out within two circular stone huts or clocháns. One (Structure G) was located to the northeast of the stone enclosure, the other (Structure D) formed part of a conjoined, figure-of-eight plan clochán (Figs. 6.33, 6.34 and 6.84). The structures were slightly smaller, though similar in construction to the two clocháns (A and B) thought to have been used as domestic buildings. Similar activity was identified nearby at Church Island, Co. Kerry (IID:053) where slag was associated with an occupation deposit in and around the stone setting of a wooden circular structure (later replaced with a stone clochán; Fig. 6.85). A possible smithing hearth associated with the wooden structure was also identified (O’Kelly 1958).

Another ecclesiastical site, St Gobnet’s House in Ballyvourney, Co. Cork (IID:186; O’Kelly 1952), also had evidence for smithing within a stone-walled circular structure (Figs. 6.86 and 6.87). Unfortunately, the stratigraphy and dating of the site was very low resolution but Phase 2 appears to have seen extensive ironworking activity within the eponymous ‘house’. Phase 1 on the site had evidence for rectangular structures, but the majority of the ironworking evidence was associated with Phase 2 (O’Kelly 1952).

**Rectangular Structures**

The specialised ‘sunken forges’ discussed above had rectangular plans but it seems that more conventional rectangular structures were also used for smithing in the early medieval period. Some of these may have been specialised buildings. Unsurprisingly, considering the known sequence of early medieval buildings changing from circular to rectangular over the period (see above), many of the rectangular buildings containing smithing were dated to the later part of the early medieval period.
At Clonfad, Co. Westmeath (IID:058; Stevens 2009) the ephemeral remains of a smithy or forge measuring between 9.5m and 7m in length and 7.5m in width were identified in the south-eastern quarter of the site (Fig. 6.88). No traces of the walls of the structure survived though differential charcoal and slag deposition suggested internal partitions. Narrow gullies survived on its northern and southern sides as well as a damaged stone footing that could have related to an anvil or smithing hearth (Stevens 2009, 33; Fig. 6.47).

At Killickaweeny 1, Co. Kildare (IID:122) three structures were identified in close proximity to the ironworking area (Walsh 2006; 2008; Fig. 6.89). Structure 3 was interpreted as an outhouse, possibly related to Structure 2 which was more substantial. It consisted of a sub-rectangular slot trench measuring c. 9m x 7m with three internal post holes and a clear entrance in its northeast corner (Fig. 6.90). If the postholes are seen as a continuation of the exterior wall to create a small porch/internal division, the shape for the structure can be paralleled with the snail-shape smithy from the Iron Age Bryn y Castell hillfort in Wales (Figs. 6.91 and 6.92). This shape may have been chosen to decrease the amount of light coming into the interior of the building, making it more amenable to iron smithing (cf. Crew 1987, 93). Structure 4 measured 2m x 2.7m and was defined by four stone-packed postholes arranged as a rectangle. It was situated within the ironworking area.

None of the structures discussed from Killickaweeny 1 can be definitively associated with smithing but it is certainly possible that one at least may have served as a forge. Similarly, structural evidence identified within the ringfort at Mackney, Co. Galway (IID:149) in the form of eleven post-holes spatially associated with smithing may represent a forge building, though no clear pattern could be discerned by the excavator (Delaney 2009a, 26). Indirect evidence for a rectangular building came from Kilmacthomas Area 16, Co. Waterford (IID:124) where a group of features in the ironworking area were grouped very close together, possibly suggesting they were enclosed within some kind of structure (Tierney and Elliott 2008, 105).

**Open Air**

While there is clear evidence for smithing within forge or smithy structures in the early medieval period, and possibly also earlier, there is also evidence for smithing taking place in unsheltered, and occasionally isolated, areas. Some of this is likely to relate to ad-hoc, small-scale smithing but other isolated, open sites have been interpreted as liminal places, playing host to marginal/ised smiths working on the fringes of society (see discussion in Chapters 7 and 8; Fredengren 2002; O’Sullivan 2009).
Two crannogs, Bofeenaun, Co. Mayo (IID:031; Keane 1995) and Sroove, Co. Sligo (IID:184; Fredengren 2002) had evidence for open-air smithing on stony pavements on artificial islands. The lack of buildings on these crannogs and the relatively small quantities of slag from Bofeenaun (74kg) and Sroove (exact quantity not known) suggest these do not indicate medium or long-term occupation, more likely representing single episodes of use. However, the possibility that slag was discarded in the water surrounding these places does make interpretation of scale difficult.

Other, more ephemeral, evidence for smithing came from the base of the enclosing ditch of a settlement enclosure at Dun Emer, Co. Dublin (IID:090). A rough metalled or cobbled surface was found and was tentatively associated with ironworking (Giacometti 2007b). A pavement of stone slabs, thought to have been used as a work surface, was also identified from Phase 2 at Altanagh, Co. Tyrone (IID:005; Williams 1986).

**Associated Industries**

The production of iron, particularly smithing, requires the same hearths, fuel, buildings and, in some cases, tools as those used for a number of other pyrotechnical industries including both glass/enamel working and non-ferrous metallurgy (cf. Hodges 1979; Henderson 2000a). A significant number of sites in this study indicate that these industries were sometimes carried on in parallel with ironworking (see Tables 6.16 and 6.17). This is an important observation as it raises the possibility of ironworkers also practicing other crafts and vice-versa. However, the limited evidence for non-ferrous working within smithing hearths seems to suggest that the two were carried out by different practitioners, or at least in different places within sites (see further discussion in Chapters 7 and 8).

No site dedicated to smelting (i.e. with no smithing evidence) also had evidence for non-ferrous metallurgy, with the possible exception of Tullyallen 6, Co. Louth (IID:196), though the identification of both smelting and non-ferrous metalworking on that site is based on one piece of enigmatic slag that may relate to either process (Young 2003c). A significant number of sites produced both smithing evidence and evidence for non-ferrous work in the form of crucibles, moulds, hearths etc. One Iron Age smithing hearth – F165 from Rath na Ri, Co. Meath (IID:188) – had evidence for a dual use; fragments of crucibles and moulds indicated bronze casting was a regular activity on the site, carried out in the same hearth as the iron smithing (Crew and Rehren 2002).
Four sites dating to the early medieval period: Reask, Co. Kerry (IID:176), Clonfad, Co. Westmeath (IID:058), Garryduff 1, Co. Cork (IID:103) and High Island, Co. Galway (IID:114) had smithing hearths apparently also used for non-ferrous metallurgy. At Reask, hearth F162 contained crucible fragments thought to relate to non-ferrous metalworking or possibly glass/enamel working (Fanning 1981, 110). Similar evidence was found in proximity to hearth F92 at Garryduff 1 in the form of crucible fragments and a blob of glass (O’Kelly 1963, 99-101). A fragment of a crucible was also recovered from hearth F96 at High island, located beneath, and predating, a stone clochán or cell (Young 2006b).

Hearth F30 from Clonfad had clear evidence for both secondary smithing and brazing – the coating of iron in bronze – of iron bells (Stevens 2009; 2010). This activity seems somewhat different in character to those above where the working of non-ferrous metals and glass may have had no direct connection with a specialist smith. At Clonfad, it is likely that it was the smith himself who undertook the brazing of the bells, within the same hearth that produced the bells.

**Summary and Key findings**

Previously, there has been very little understanding of the variety and extent of smithing in the Irish Iron Age and early medieval periods. High quality iron objects such as the Lough Mourne and Rathinaun Axes and the decorated iron collars from Lagore (Scott 1978b; 1990, 49-55) have hinted at an industry that must have been developed, spatially extensive and probably specialised but the archaeological record, until very recently, had failed to provide evidence for how or where such complex artefacts would have been produced.

This review of the archaeology of early smithing has demonstrated the wide variety of evidence available, characterising the finds, features and structures associated with smithing in the Iron Age and early medieval periods. This characterisation is highly significant and represents a major advance in our understanding of Irish iron technology. It provides a sound basis for interpreting the role of iron in its social context, attempted in following chapters. It also creates a new foundation for future technical and interpretive investigations of Irish iron smithing technology. The key findings from this review are presented in summary form below.

**Fuel**

Early medieval smiths relied primarily on wood charcoal as a fuel, commonly oak but also other species including alder, birch, hazel, ash and elm. Peat charcoal was also used in the
early medieval period, though evidence for it was rare. It may be that it has not been recognised in the archaeological record or that it was a fuel used only in the absence of accessible wood charcoal.

Charcoal production was rarely carried out in the same location as smithing, with wood charcoal probably produced close to wood sources before being transported to smithing sites. The occurrence of charcoal kilns, which were not contemporaneous, on some smithing sites, reflects a similar situation on a number of smelting sites in this study (see Chapter 5). While the dating of such features is made difficult by the use of old, mature wood, it seems likely that these kilns represent activity undertaken after the abandonment of ironworking sites and the regeneration of woodland.

Tools

Evidence for iron tools clearly associated with smithing is very rare and a comprehensive review of such artefacts was not attempted in this study. However, extensive evidence was identified for stone tools associated with smithing. Stone anvils were found in situ on a number of sites, with one example of a stone anvil-base for use with an iron anvil identified from Lowpark, Co. Mayo (IID:148; Gillespie 2008; Higgins 2008; Gillespie 2010). Evidence was also identified for the use of concave mortar-stones by smiths, possibly for the shaping of iron or the consolidation of blooms. These concave stones represent a new artefact-type which can be used as an indicator of smithing and may be related to the enigmatic ‘bullaun stones’ traditionally associated with early medieval ecclesiastical sites (Dolan 2009).

Other tools associated with smithing include stone hammers and sharpening stones. However, there is some difficulty in identifying hammers which were clearly used in smithing as they can be multi-purpose. Similarly, sharpening stones were not associated exclusively with smithing and would have been used frequently in non-ironworking contexts.

Smithing Hearths

Smithing hearths included in this study are variable in both shape and size and there appears to be no chronological pattern to their morphology. Indeed, the size and shape of hearths can vary within sites and probably relates to the function of particular hearths as well as the size, shape and type of iron object being produced. Hearths were often unlined but many had clay and/or stone linings. They were blown using bellows, through a clay tuyere. Occasionally stone linings are found on a single side of a hearth, most likely originally used to protect the edge of the hearth lying under the tuyere and thus closest to the hottest part of the hearth.
Limited evidence was identified for the construction of hearths with low-superstructures made of clay and stone. In at least one case, at Clogher, Co. Tyrone (IID:055; Scott 1990; Warner 2000), this may have been done for ease of use with a raised anvil stone. Otherwise smithing seems to have been carried out at ground level, possibly helping to prevent the distribution of sparks and thus reduce fire-hazard.

**Tuyeres**

Tuyeres were identified from a significant number of, primarily early medieval, sites in this study. Re-assessment identified two broad types. The first included ‘large tuyeres’, measuring between c. 10cm and 15cm in diameter, with conical apertures 1.5cm and 3cm in diameter on their vitrified faces. The ‘small tuyeres’ did not have conical apertures and had thinner, less robust bodies. Large tuyeres are exclusively associated with ironworking, specifically smithing, and were not used in smelting as previously suggested (Scott 1990). This is very significant as it suggests tuyeres might reasonably be seen as diagnostic of smithing in Irish contexts. The smaller tuyeres were associated with non-ferrous metallurgy and do not appear to have been used when working iron. Again this is significant, but in this case the tuyeres might possibly be used as diagnostic artefacts indicating non-ferrous pyrotechnologies.

**Slag**

Smithing slag from sites in the study conforms to known understandings of bloomery smithing technology (outlined in Chapter 2). SHCs were identified on a large number of sites, with hammerscale recorded from a smaller number. Examples of smithing pans were reported from a number of sites in the study, indicating smithing over substantial periods of time on some sites.

**Bloom and Bar**

Evidence for unconsolidated blooms was discussed in Chapter 5 but their production, *i.e.* primary smithing, which is commonly associated with smelting, seems, in at least some cases, to have taken place away from smelting sites in this study. This suggests the transportation of raw blooms. It is assumed that consolidated blooms as well as bar/stock iron was also transported but very few examples of these have been identified archaeologically. No evidence was found for standardised stock iron similar to the currency bars known from the British Iron Age.
Associated Features and Structures

The Iron Age evidence for smithing structures was sparse. There is no evidence for any specialist forge-buildings, though there is some evidence for the use of shelters in a few cases. However, this study has identified significant evidence for specialist buildings in the early medieval period dedicated to smithing, including a series of rectangular ‘sunken forges’. These buildings were rectangular and had sunken floors which could contain hearth pits, storage pits, anvils, concave stones and other features. It seems clear that these represent dedicated industrial buildings, built for the purpose of smithing and used by experienced smiths. A small number of non-sunken rectangular buildings were also associated with smithing in the early medieval period and some of these may also have been dedicated ironworking areas.

Early medieval smithing also took place in circular structures, normally associated with domestic activity. The smithing in these buildings was different in nature from that carried out in sunken forges and was probably on a smaller scale. A small number of circular ecclesiastical, stone-built, structures may indicate a slightly different approach to smithing. These structures were not classic early medieval houses, as found on ringforts, and may indicate a different approach to ironworking within ecclesiastical sites (see further discussion in Chapter 8).

The construction of particular building types, solely related to smithing, is highly suggestive of prolonged and specialised production. At the same time, evidence for a myriad of more prosaic buildings with evidence for smithing suggests a broad spectrum of practice right down to un-associated, isolated hearths that might represent more ad-hoc, small scale smithing.

Associated Industries

Ironworking was associated with other pyrotechnical industries in both the Iron Age and early medieval periods but overall, there is surprisingly little direct evidence for the working of both materials in parallel within a single hearth. This suggests smithing was commonly practiced separately from non-ferrous metallurgy, glass and enamel working and hints that the practitioners of smithing may have been separate also. However, there is clear evidence, in a small number of cases for hearths used for multiple industries, suggesting the possibility of groups of craftspeople with different skills or possibly multi-skilled craftspeople.
Previous chapters have outlined in detail the technology and archaeology of iron production in early Ireland. What follows will build on this understanding, putting the activities of smelters and smiths in their social context. The focus in this chapter is on the Iron Age, taking a regional case study in the Irish midlands and considering the processes behind the introduction of iron technology as well as the organisation of society implied by the distinctive landscapes of smelting and smithing in the study area. The evidence for iron technology identified in this study includes an unprecedented new corpus of information for the Irish Iron Age which has long had a restricted range of archaeological evidence (Cooney and Grogan 1994; Raftery 1994; Armit 2007; Waddell 2010). The practice of smithing and smelting in the landscape, small-scale, personal activities, offer a rare glimpse of Iron Age life beyond the communal activities represented by votive deposition and sacrifice, ‘royal’ sites, linear earthworks and roadways, which have dominated understandings of the Iron Age in Ireland.

The ‘Enigma’ of the Irish Iron Age

The archaeology of the Iron Age in Ireland can be characterised as essentially ‘different’: different from the periods preceding and succeeding it and from the Iron Ages and Romanised periods of Britain and the European Continent. Raftery’s (1994) ‘enigma’ and Armit’s (2007, 133) ‘archaeology of the non-routine’ refer to the root of this difference: the scarcity of evidence for the mundane, the everyday and the familiar, for Raftery’s (1994, 112) ‘invisible people’.
Settlement

There is very little evidence for the form and nature of domestic settlement in the Irish Iron Age (Raftery 1994; Armit 2007, 131-132; Waddell 2010, 333-334). This is despite focused efforts by the state-funded Discovery Programme (Waddell 1997; Armit 2007, 131) and the huge number of excavations carried out during the Celtic Tiger boom (Becker et al. 2008).

Hillforts, the classic Iron Age settlements of southern Britain (Cunliffe 2005), seem to have been a largely Late Bronze Age phenomenon in Ireland (Armit 2007, 131-132), with only limited, often industrial (e.g. Raftery 1969; Warner 2000; Crew and Rehren 2002; Grogan 2005a, 244; Rehren 2007), use in the Iron Age. Where potential evidence for Iron Age settlement has been identified on hillforts, for example at Clogher, Co. Tyrone (Warner 1973b; 2000; 2009) and the Rath of the Synods, Tara, Co. Meath (Grogan 2008), it is clear that they do not represent the dwellings of the majority of the Iron Age population.

Some possible Iron Age houses have been identified (Walsh 1995; Ó'Drisceoil 2007b; McLaughlin 2008; O'Brien 2009b) and others postulated (Henderson 2000b; 2007), but many have issues with dating and/or interpretation (Ó'Drisceoil 2007b, 22-23). A recent all-island review of excavations with Iron Age dates or phases identified only thirty ‘post or plank constructions of either habitational or workshop character’ dating between 700 BC and 400 AD (Becker 2009, 354). It is not clear exactly how many of these related solely to industrial/craft activities and the possibility that some might relate to ritual activity should also be considered.

Clearly, this is a staggering small number of buildings known from the island over a period of more than a millennium, particularly when compared with the richness of the archaeological records of the Bronze Age (e.g. Grogan et al. 2007; Waddell 2010, 115-289; Ginn and Rathbone 2011) and early medieval periods (e.g. O'Sullivan and Harney 2008a; 2008b; O'Sullivan et al. 2010a; 2010b).

The same study included a very significant number of sites, spread throughout the island, with ‘settlement evidence’ (Becker et al. 2008, 25-34). However, these sites were identified using a very broad definition of evidence for settlement which included isolated pits, postholes and hearths with Iron Age radiocarbon dates. Ephemeral isolated features like these certainly serve to confirm the existence of human activity in the Iron Age, though they tell us little about the form and nature of their settlements. The need to call on such insubstantial evidence is exacerbated by the scarcity of pottery and other domestic artefacts in the archaeological record (Raftery 1994; 1995).
That people lived and farmed in the Iron Age landscape is not in doubt; indirect evidence from environmental studies show people were carrying out both pastoral and arable farming throughout the Iron Age, though there were lulls in activity in different places at different times (cf. Weir 1995; Molloy 2005; McDermott et al. 2009). At the same time there is also good evidence for woodland regeneration and the closing in of the intensively cleared Late Bronze Age landscape (Molloy 2005; McDermott et al. 2009), possibly related to a reduction in population (Weir 1995). It is clear that the population of Ireland in the Iron Age, in contrast to neighbouring communities in Britain and continental Europe (Hill 1995b), lived in ways which left little archaeological trace of their everyday lives, though evidence for communal projects, ritual and elite culture is comparatively visible.

‘Royal Sites’

The four ‘royal’ sites of Iron Age Ireland: Tara, Co. Meath (Newman 1997), Navan, Co. Armagh (Waterman 1997; Mallory and Lynn 2002), Knockaulin, Co. Kildare (Johnston and Wailes 2007) and Rathcroghan, Co. Roscommon (Waddell et al. 2009) were important centres for communal gathering and rituals in the Iron Age. Their royal associations stem from early medieval understandings of the sites and there is no evidence that they served as seats of military power. Excavations at Knockaulin and Navan have demonstrated significant ritual events occurred on the sites around the first centuries BC/AD and limited excavations at Tara indicate similar activity (Roche 2002). The sites formed elements in wider landscapes associated with earlier burial and ritual monuments. Raffin Fort, Co. Meath has been identified as a smaller-scale, undocumented, ritual centre analogous to the ‘royal’ sites (Newman 1993; 1995) and it is likely that other large enclosed hilltop sites with burial mounds and associated ritual landscapes served similar functions in the Iron Age (cf. Raftery 1994, 79-81; Newman 1995; Armit 2007, 133).

Linear Earthworks and Routeways

Linear earthworks of varying forms and sizes have also been identified across the island, with a number dated through excavation to the Iron Age (cf. Raftery 1994, 83-94; Waddell 2010, 379-383). Their function is unclear but they are unlikely to have had a purely military role (Raftery 1994, 88); some may have served as boundary markers, either territorial or ritual (Aitchison 1993; Armit 2007) but their primary role may have been as ‘monuments to labour’, embodying the community, competition and friction involved in their construction (Giles 2007c). Whatever their function, these large-scale construction projects imply authorities and populations of sufficient strength, complexity and/or common purpose to undertake such monumental schemes.
Similar scales of effort and organisation would have been required for the construction of the largest of the Iron Age trackways excavated at Corlea Bog, Co. Longford (Raftery 1990), built around 148 BC, and probably continuing for over two kilometres to Derraghan More, also in Co. Longford (Raftery 1996). Evidence for other Iron Age trackways, of lesser scale than the Corlea-Derraghan road, have been identified throughout the midlands in counties Offaly, Tipperary, Longford and Westmeath (e.g. Raftery 1996; Gowen et al. 2005; McDermott et al. 2009, 51). Drinking vessels, bowls and tubs associated with excavations at Corlea may suggest feasting was used to mobilise people in its construction (Waddell 2010, 334), though a large number of associated finds from a complex of Iron Age trackways at Edercloon, Co. Longford were deposited with ‘a strong degree of intent’, implying a possible ritual origin (McDermott et al. 2009, 57).

Deposition and Sacrifice

The deposition of objects in watery places was an important rite in Bronze Age Ireland and it continued in the Iron Age with a break following the Late Bronze Age, resuming around the third century BC with deposition of La Tène style metalwork of native manufacture (Raftery 1983; 1984; 1994). More recently, clear evidence has been identified for the deposition of human bodies in bogs in Ireland as part of sacrificial rituals (Kelly 2006b; 2011b) and some bog butter, possibly also associated with ritual deposition, dates to the Iron Age (Synnott and Downey 2004; Downey et al. 2006; McDermott et al. 2009, 52). These practices are generally accepted as representing religious offerings and are linked with similar practices across the British Isles and Europe (e.g. Bradley 1990; van der Sanden 1996).

Burial

A recent survey of the evidence for Iron Age burials in Ireland by McGarry (2008) has shown the high level of continuity in visible burial practices between the Bronze and Iron Ages in Ireland (see also Cooney and Grogan 1994, 199-200). Iron Age burials were generally cremations, often associated with curvilinear ditches, were not clustered in large groups and had limited grave goods (McGarry 2009). However the number of known burials is extremely small and the normative burial ritual in Iron Age Ireland is archaeologically invisible (Raftery 1981; McGarry 2009). The small number of formal articulated burials date to the end of the Iron Age and are indicative of strong influences, or the movement of very small numbers of people to the island in the Late Iron Age (McGarry 2008).
A Post-Celtic Regional Iron Age

The essential ‘difference’ of the archaeology of the Irish Iron Age has traditionally been ignored in favour of a homogenising ‘Celtic’ paradigm which predates the development of archaeology as a discipline (Ó'Donnabháin 2000). This sought to explain the existence of a Celtic language on the island in the first millennium AD through an influx of Celtic-speaking invaders (e.g. Herity 1977; de Paor 1986). However, the problems identifying evidence for ‘Celtic’ invasions in the archaeological record have long been recognised (e.g. Raftery 1994, 220-228) and even the idea of a coherent ‘Celtic’ cultural or ethnic identity in prehistory has been questioned (e.g. James 1999; Collis 2003). The existence of Celtic languages in the British Isles by the end of the first millennium BC is probably better explained through long-term processes of contact and interchange on the Atlantic facade of Europe (e.g. Cunliffe 2009; 2010; Waddell 2010, 302-305). Giles (2007c, 103-104) has argued, in relation to Iron Age Yorkshire, for the futility of the invasion/continuity debate, suggesting a move towards an understanding of past societies in terms of relational identities created and performed through the routines of daily life (see also Brück 2004; Giles 2008).

The traditional ‘Celtic’ model of a warrior based society with clear hierarchies was based on classical sources and early Irish heroic literature (Hill 1995b, 73). This is a model which works well in some places in the Iron Age, for example hillfort-dominated southern Britain, where Cunliffe has argued tribal chiefdoms developed from the sixth century BC on (Cunliffe 1984a; 1984b; 2005, 588-594). However, alternative models of society, including heterarchical systems where social power derived from many, cross-cutting systems of social relations, have been used to challenge hierarchical views of the Iron Age (e.g. Ehrenreich 1991b; Hill 1995a; Wailes 1995; Giles 2007b; 2007c). Recent approaches have emphasised the importance of regional communal identities in the Iron Age, though how this manifested in terms of ‘chiefdoms’, ‘tribes’, kin-groups or other ethnic or political entities is debated (cf. Haselgrove and Moore 2007, 10; Haselgrove and Pope 2007, 11-12). Sharples (2010) has recently suggested that hill fort communities may have been characterised by the suppression of hierarchy and an emphasis on collective identity. He proposes that a lack of elite burial rites, lack of differentiation in housing size and conspicuous absence of elite material culture until the later Iron Age in this region can be interpreted as a lack of strongly differentiated social hierarchy. He argues that ironworking in the Middle Iron Age period became increasingly specialised and controlled by a group of metalworkers or artisans with ‘peripheral social status’, who were able to develop exchange networks which ran ‘counter to the community-based power structures that were symbolised by the hillfort ramparts’ (Sharples 2010, 138).
Short-lived episodes of production suggest itinerant smiths, producing complex and sophisticated items such as currency bars, agricultural equipment and horse-gear. Yet the general rarity of this material and its frequent appearance in hoards located at boundaries, suggests iron had a complex series of symbolic meanings and social uses, rather than being primarily used by elites to reproduce social status and retain a warrior aristocracy through gift-giving.

The traditional picture of the Irish Iron Age envisages a warrior elite, intrusive (e.g. Warner 1991) or native (e.g. Raftery 1994; 2005), the users of La Tène material culture, at the top of a hierarchical system with the other levels of society largely separate and invisible in the archaeological record. Differences in the distribution of such La Tène material led to the proposition of a regional Irish Iron Age, with the south of the island, devoid of La Tène material culture, host to a remnant Late Bronze Age cultural zone (Caulfield 1977; Raftery 1998). This has been seen as implying a La Tène/non-La Tène division on the island, with the La Tène material representative of an elite section of society somehow separated from the wider ‘non-La Tène’ people of the Island (Raftery 1998). Woodman (1998) has pointed out that this treats La Tène material as a homogenous whole rather than recognising regional chronological and spatial differences throughout the island.

Cooney and Grogan (1991; 1994) argued for the continuity of Late Bronze Age social structures in the Iron Age, with fine metalwork continuing to form the basis of status and social ranking. More recently, Armit (2007) has pointed to a dichotomy of communal regional identities expressed through large-scale, labour intensive constructions and a preoccupation with the display of individual social difference through elite La Tène metalwork and, later, exotic Roman material culture. He explains these varying structures for the display of social power through a heterarchical organisation of society. Collis (2007) saw evidence in the communal architecture and metalwork hoards of the centuries spanning the birth of Christ for short-lived incipient state organisation in Ireland with regional polities similar in size to those seen in the early medieval period.

It seems clear that regional identities, probably attached to communal ritual centres of varying sizes were important in the Iron Age, though the scale and coherence of such constructed identities must have fluctuated over time. There is little evidence for social difference in the settlement record; royal sites were not the residences of rich elites. Instead, the limited evidence suggests most of the community lived and died in similar, archaeologically invisible, ways. Social difference was expressed through metalwork and presumably other material
culture but much of this metalwork (e.g. horse gear) may have been held by families or kin groups, suggesting community identity at various scales was given priority. Evidence from this study suggests the midlands in Ireland may have been an important region for iron production, though it is not clear to what extent this related to political or ethnic regional identities (see further discussion below).

Forging the Iron Age in the Irish Midlands

If the existence of regional identities, manifested in communal ritual and monuments, is accepted in Iron Age Ireland then an obvious problem arises: identifying the extent of such regions archaeologically. Linear earthworks have been seen in the past as possible defensive markers of territorial boundaries (Lynn 1982; Condit 1989; Lynn 1989) but their rarity, problems with dating and contemporaneity (Raftery 1994) and the possibility that they had other functions (e.g. Aitchison 1993; Giles 2007c) mean they are not very useful in reconstructing regional boundaries. Similarly, the ‘royal’ sites of the Iron Age have been read as regional centres but their small number and uneven distribution and the lack of archaeological material connecting them to their hinterlands makes the proposition of boundaries difficult and highly speculative.

There are also obvious problems in extending later boundaries and understandings of Iron Age monuments into the past. Kelly’s (2006b; 2006a; 2011b) argument that bog bodies and other items deposited in bogs represent boundary deposits demarcating tribal divisions in the Iron Age relies on a very optimistic projection of medieval boundaries back into the first millennium BC. Bogs and other watery places such as rivers and lakes naturally form boundaries or obstacles and will inevitably coincide in many cases with historical divisions. It is likely given the overwhelming association of metalwork deposition in Iron Age Ireland with watery places (Raftery 1983; 1984) and not dryland sites (where many boundaries must have existed) that such deposition was not primarily related to marking boundaries.

Iron production sites included in this study represent a significant new window through which the Irish Iron Age can be viewed. They also provide an opportunity to define at least one putative region in the Irish midlands, concentrated in mid-Leinster. Known Iron Age iron production sites are not spread evenly across the island (Fig. 7.1); a significant cluster (19 sites; 35%) are located in the lowlands of Leinster, in counties Meath, Westmeath, Offaly, Kildare and Laois (Fig. 7.2). They range in date across the Iron Age, including the earliest dates for iron smelting in the country (see below), with a concentration in the last four centuries BC (Table
Most were smelting sites with similar layouts and morphologies, suggesting a common tradition of working in the region.

Importantly, the concentration does not appear to result from modern excavation bias. The majority of the sites in the case-study region were excavated along particular sections of the routes of the M4/M6 and M7 motorways (Fig. 7.5). Most of the sites were devoted to smelting and cluster in areas close to the extensive midlands bogs (Fig. 7.6). This relationship suggests that the distribution may relate to the availability of bog ore. Iron Age smelting sites are correspondingly rare in the vicinity of Dublin, an area lacking raised bogs, despite extensive excavations associated with commercial development and the construction of the M50 ring-road and the various radial routes out from the city. Other concentrations of Iron Age smelting can tentatively be identified in north Connacht, possibly also associated with raised bogs, and in County Cork, though a lack of bogs in this area might suggest the exploitation of mineral ores (Fig. 7.6).

The borders of the case-study area (Fig. 7.2) are not argued here to be necessarily representative of the borders of an actual Iron Age polity or tribal area. Such boundaries are difficult to identify, would have changed through time and may not have left physical traces. In fact, looking for fixed boundaries and drawing lines on maps may misunderstand the nature of boundaries in what was probably a mobile pastoral society (see below); ownership may not have related to land itself but rather to principles of access, movement, control and use (cf. Giles 2007c, 109). However, it is argued that the organisation of iron production within the region, whether within or across actual political or tribal areas, does allow some understanding of the organisation of society in the region and the part iron producers played in it.

The Regional Context

The case-study region is relatively well studied in terms of Iron Age Ireland. Paleoenviromental evidence from two adjacent bogs (Oldcroghan and Toar) within the study area, in Co. Offaly, record a closing up of the landscape from the sixth century BC indicating a change in farming practices, a pattern seen in other pollen records from the Irish midlands (McDermott et al. 2009, 58-60). A resumption of clearance activity was identified in the vicinity of Oldcroghan bog following the deposition of a human body around the beginning of the third century AD (Plunkett et al. 2009), though clearance in the vicinity of Toar bog was not seen until the beginning of the fourth century AD (McDermott et al. 2009, 60). The evidence available suggests people in the region were living in a less open landscape than that of the Bronze Age, probably with lower population densities.
Nomadic Pastoralism

This closing in of the landscape was accompanied by a change in settlement form from substantial timber houses and even villages in the Bronze Age (e.g. Waddell 2010, 213-232; Ginn and Rathbone 2011) to more ephemeral dwellings. Raftery (1994, 113) pointed to the possible existence of tents in the period and it seems eminently possible that nomadism or transhumance, associated with a pastoral economy may have been predominant (cf. Raftery 1994, 113; Armit 2007, 135; Becker 2009, 356). Very few faunal assemblages are available from the Iron Age but one from Knockaulin, Co. Kildare, within the study area, included significant numbers of young calves, consistent with a pastoral way of life – often associated with nomadism (Cribb 1991, 15-16) – including active management of cattle for the production of milk (Crabtree 2007). Bog butter, used in votive deposition in the Iron Age (Downey et al. 2006), represents one product of this pastoral way of life. At the same time there is evidence for arable agriculture in the Iron Age (e.g. Molloy 2005). Beehive querns, which clearly were not portable, may be the most obvious manifestation of this. However, they may date quite late in the Iron Age and are rare in the case-study region (cf. Caulfield 1977). Also, the lack of use evident on many examples and their association with votive deposition may indicate they were special items reserved for particular, seasonal functions, such as the preparation of alcoholic drinks for feasting (cf. Raftery 1994, 123-124; Waddell 2010, 334-337).

The particular preoccupation with horsegear and roads in Iron Age Ireland, manifested in votive hoards of bits and so-called ‘pendants’ or ‘leading pieces’, a number of which have been identified from the study region (cf. Raftery 1983; 1984), could be connected with a mobile way of life. The most likely interpretation for the pendants is that they had a decorative function (Raftery 1994, 109-110), and recent experimental work suggests they may have held tassles on the tops and sides of a horse’s head (McGrath 2011). They are a uniquely Irish form (Raftery 1984, 47), suggesting a particular preoccupation with the display of horses in the country. They could have carried or drawn tents, domestic equipment and other items when camp was struck. Indeed, the abandonment of pottery vessels in the Iron Age: fragile, heavy, bulky and impractical during such travel, may have resulted from a change to more itinerant life-ways. The abandonment of pottery has also been associated with a move to a pastoral economy (Cunliffe 2005, 78). At the same time, the potential symbolic and practical importance of horses in other areas of life e.g. warfare, ploughing and long-distance trade/transport mean they need not necessarily be associated with nomadism or transhumance.
Social Stratification and Community

Hill (1995b, 89) argued that the appearance of royal sites and metalwork deposits from the third century BC in Ireland were indicative of ‘a considerable degree of social hierarchy’. Similarly, Robertson (1992) saw the monumental constructions at ‘royal’ sites, particularly at Navan, as representing responses by elite groups in Iron Age society to exterior or interior stresses and challenges to their authority. However, when the much later early medieval and classical texts are disregarded, there is very little archaeological evidence for the existence of hierarchical kingship in Iron Age Ireland (cf. Collis 2007; above). However, these large communal constructions do imply the existence of some form of organising authority.

While archaeological evidence is lacking in general, there is little evidence for a strictly hierarchical, tribal chiefdom or kingdom in the study region during the Iron Age. A mobile way of life, following pastoral rhythms, without any permanent settlement sites would have limited opportunities for the expressions of social difference through material wealth. Practically, there would have been a limit to the amount that could be carried and the shared experience of movement and temporary settlements would mitigate against extreme social difference. Property, in the form of animals, carts/chariots, tents, metalwork etc may not have been held exclusively but rather communally, through principles of access, use and control (cf. Giles 2007a, 109). Cunliffe (e.g. 2005, 310), in the context of the British Iron Age, has argued that economies focused on pastoralism were less likely to develop politically coherent tribes with centralised, defended foci. While there must have been ranking within society, its overall organisation might better be understood as heterarchichal (Crumley 1979), with individuals having relational identities constantly negotiated through practice and performance (Ehrenreich 1991b; 1995; Brück 2004; Giles 2007c; 2008). In this view, individuals in society did not inherit rank and identity but were active agents in the creation of their own identities through their day to day actions, but also through transformative rites and rituals.

Aspects of social identity and stratification were played out, probably seasonally, at communal ritual sites in the study region, particularly large hilltop enclosures. Three possible examples of such sites are known from the study area: Knockaulin, Co. Kildare, Ballydavis, Co. Laois and Uisneach, Co. Westmeath. Archaeological evidence from Uisneach for activity in the Iron Age is limited but a penannular enclosure on the hill may date to the Iron Age (Schot 2006). A number of different excavations, none of which are fully published, have been undertaken in the vicinity of the archaeological complex in Ballydavis townland, Co. Laois. The earliest, Ballydavis 1 (I1D:020), uncovered four ring ditches associated with burial, pits and a series of features interpreted as furnaces situated on a low knoll (Keeley 1996a; 1996b; 1999). Later
excavations at Ballydavis 2 (IID:021) focused on a large hilltop enclosure, over 100m in diameter, and uncovered a number of burials, ring ditches, ironworking evidence and at least two house/hut structures located outside the enclosure (Young 2005d; Fegan 2006; McGarry 2008). Excavation at Ballydavis 3 (IID:022) took place outside but in proximity to the hilltop enclosure and produced two smelting furnaces and a pit partially surrounded by a slot trench (Ó'Maoldúin 2006; 2010). Ballydavis was part of a wider ritual and burial landscape, best preserved in the Great Heath of Co. Laois, located c. 1.5kms to its northeast (Feehan 2002).

Knockaulin, Co. Kildare was one of the four major ‘royal’ sites recorded in the early medieval period, though there is no evidence from the site for its use as a settlement or military site (Johnston and Wailes 2007). Instead, excavations at the site revealed a series of monumental, open air enclosures which were followed by a series of feasting events, all of which dated to the centuries around the birth of Christ (Wailes 2007). The plans of these enclosures have been paralleled with similar structures and enclosures at Navan, Co. Armagh (Lynn 1991b). Knockaulin, like Ballydavis, was situated on a prominent hill and formed part of a wider landscape of ritual and burial monuments, with roots in the Bronze Age and earlier, preserved in the Curragh, Co. Kildare, which probably incorporated Knockaulin at one point (Clancy 2005; Hicks 2007; Feehan 2008).

Knockaulin has been interpreted as a site of communal ritual and gathering where sacrifice and feasting took place, probably yearly, between late Spring and Autumn (Crabtree 2007; Johnston 2007c; McCormick 2009). It is not clear from the available information if similar gatherings took place at Ballydavis but the large enclosure might well have been used in a similar way. The monumental scale of both sites would have required episodes of labour exchange, interaction and even rivalry between different social groups (Sharples 2007). Following construction, the sites would have stood as monuments to that labour and competition.

The large ritual gatherings envisaged at Knockaulin (Johnston 2007c) would have been important opportunities for the creation of individual and group identities. It would have been an appropriate venue for transformational ceremonies and rites of passage such as marriage, funerary rituals and investitures. The gathering of large groups would also have provided opportunities for competition, gift exchange and performance. Communal consumption of sacrificed meat, boiled in cauldrons (Crabtree 2007) would have been important in publicly displaying the rank, status and social roles of individuals as sacrifices were made and portions were divided.
Liminality and Death

Deposition of votive items in bogs, lakes and rivers, including metalwork, querns, butter and human sacrifices is a long-recognised aspect of Iron Age ritual practice, at least after the fourth century BC (see above). Votive deposition of metalwork is relatively rare within the study area with two pendants or leading pieces, one from the river Boyne at Moyfin, Co. Meath and one from Kishawanny, Co. Kildare and a horse bit, also from the river Boyne, at Kinefad Bridge, Co. Offaly (Raftery 1983). Five swords, and a bronze tazza reportedly from Edenderry in Co. Offaly have an uncertain provenance (Raftery 1983, 286-287). A La Tène sword, possibly a foundation deposit, was identified from the fill of a trench in the Mauve phase at Knockaulin, Co. Kildare (Johnston 2007b).

The deposition of metalwork has been seen as representing competitive gift exchange in the Bronze and Iron Ages, a method of demonstrating individual social power (e.g. Cooney and Grogan 1994; Bradley 2007; Sharples 2007). However, the deposition of items which arguably were owned by the community or family such as human bodies, butter and quern stones might indicate religious rites that are more about communal identity than individual power. Other items of votive deposition such as horse-gear, often found in pairs indicating the drawing of carts or chariots (Raftery 1984), important for the movement of pastoral groups, might also be communal offerings from kin groups.

A number of Iron Age burials have been identified from the study area, from the Ballydavis complex in Co. Laois and the nearby townland of Cappakeel, from Carbury Hill and Hawk Hill in Co. Kildare, and also a bog body from Oldcroghan bog in Co. Offaly (cf. McGarry 2008). One burial from Ballydavis produced a unique tinned bronze box with stylistic connection to a female chariot burial at Wetwang Slack in Yorkshire, England (Keelley 1999; McGarry 2008). Burial in the Iron Age of the study region is little understood, largely due to its archaeological invisibility. However, there is an absence of ostentatious individual burials with grave goods. The box from Ballydavis is an intriguing exception to this. Both burial and votive deposition must have been to some extent communal activities and there is even some possibility that votive deposition may have been part of funerary rites. The deposition of bodies, excarnated bones or cremated remains in flowing water would leave little archaeological trace and if remains were crushed there would be even less chance of survival (McGarry 2008).
The Introduction and Development of Iron Technology

The chronology of the Iron Age in Ireland has never been well-defined, either at its beginning or its end, and its emergence has, thanks to the scarcity of archaeological evidence from the period, never truly been defined by the poorly understood introduction of iron technology. Rather, its beginning has been seen in the end of Bronze Age depositional practices and the disappearance of Dowris metalwork in the mid-first millennium BC (Raftery 1994, 36). All of the sites in this study with Early Iron Age (c. 700 BC – c. 400 BC) dates came from the case-study area, strongly suggesting it was the region where indigenous iron production was first practiced.

The very early evidence for bloom-smithing at Hartshill Quarry in Berkshire, England dating to the tenth century BC, provides secure evidence for early experimentation with iron technology in southern Britain, though iron artefacts may have been introduced even earlier (Collard et al. 2006). A similar situation pertained in continental Europe and Scandinavia where an early introduction of iron artefacts was succeeded by early, but small-scale, iron production by the tenth century BC and possibly earlier (Sørensen and Thomas 1989; Nørbach 1998; Collard et al. 2006, 406-416; Hjärthner-Holdar 2009). The early use of iron in the western ‘Atlantic’ zone of Britain is not well dated and in some areas it not clear if iron objects were produced on a significant scale prior to the end of the first millennium BC (Henderson 2007), though excavations in Wales have demonstrated significant iron production by c. 300 BC (Crew 1985; 1987; 1989a; 1989b; 1990; 1995d; 1995c; 1998).

Until recently, the best evidence for the earliest use of iron in Ireland took the form of iron skeumorphs of Late Bronze Age forms including two looped and socketed axeheads from Lough Mourne and Toome in Co. Antrim, a potential Hallstatt C period sword from the River Shannon, a riveted sheet-iron cauldron from Druumlane, Co. Cavan and an iron axe, fork and pin from a Late Bronze Age phase on Rathinaun Crannog (Scott 1974c; 1978a; 1990, 47-49; Raftery 1994, 31-35), though there are significant question marks over the dating of the material from Rathinaun (Raftery 2005, 136). The dating of these early artefacts is necessarily relative and the traditional dates for them can be seen as imprecise at best (cf. Waddell 2010, 295-300). Skeumorphic objects, while probably worked in Irish workshops following local models, do not necessarily indicate knowledge of smelting: stock iron could have been
imported in the form of blooms or artefacts. A full adoption and knowledge of iron technology can only be indicated by evidence for smelting in the form of slag or furnaces.

The Earliest Evidence for Smelting in Ireland

Two sites with very early dates associated with smelting were recently identified from Kinnegad 2 (IID:130) and Rossan 6 (IID:179), both in Co. Meath. At Kinnegad 2, a piece of slag was found in a pit deposit, dated 805-417 cal. BC (2530±60; Beta-177427), and associated with Late Bronze Age pottery. The association between the pottery and the iron slag was seen as direct and representative of ironworking in a Late Bronze Age context (Carlin et al. 2008b, 101-104). However, close reading of the specialist report (Photos-Jones 2003b) reveals that the slag was classified as a ‘vitrified clay fragment’; a category possibly, but not necessarily, associated with ironworking. Rossan 6, also had a very early calibrated date spanning 894-592 cal. BC (2610±40; Beta-177434) from a pit containing slag, but later dates from the single confirmed furnace on the site suggest this may be a result of old wood (Murphy 2004c; cf. Warner 1990).

Other early dates for smelting came from the Ballydavis complex in Co. Laois. The earliest date, 750-402 cal. BC (2424±31; UBA-11709), was returned from an oak charcoal sample from the fill of a smelting furnace at Ballydavis 3 (IID:022). Again, the date may be subject to the old-wood effect but dates from nearby Ballydavis 2 (IID:021) also spanned the Late Bronze Age and Iron Age (Fegan 2006; McGarry 2008). There is limited dating evidence from Ballydavis 1 (IID:020), including cremated bone from one ring-ditch spanning 360-46 cal. BC (2140±50; GrA-13594). Unfortunately, the slag from Ballydavis 1 and 2 was not directly dated, but the possibility remains that the smelting at Ballydavis 3 may be some of the earliest in the country.

A number of other smelting sites from the study area, including Johnstown 3 (IID:118) and Cherryville Site 12 (IID:052), Co. Kildare and Derrinsallagh 5 (IID:078), Co. Laois, had dates spanning the Early Iron Age period (Figs. 7.3-7.4). Cumulatively, radiocarbon dates from smelting sites in the study area suggest iron smelting was underway by the second half of the first millennium BC and possibly earlier, in the sixth or even seventh century BC. Evidence from Derryville Bog, on the border of Counties Kilkenny and Tipperary and very close to the case-study area (Fig. 7.2), for a change over to the use of iron axes as early as 630 cal. BC (Ó’Néill 2005, 337) suggests availability of iron tools in the seventh century, though it is not clear if these tools were made locally or imported.

A significant number of smelting sites in the case-study region and nationally date to the last four centuries BC (Figs. 7.7-7.9), indicating the commonplace production of iron blooms,
though on a small scale (see below). This appears to have been a period of generally increased activity in the Irish Iron Age, with far less sites dating to the phases before and after it (Becker et al. 2008; Becker 2009). There is a marked decrease in the number of iron production sites in the region dating to the first four centuries AD (Fig. 7.3-7.4), coinciding with the Roman occupation of Britain. It is possible that a significant increase in the availability of iron in Britain in the period (cf. Cleere 1981; Cleere and Crossley 1995; Pleiner 2000, 41-45, 50; Schrüfer-Kolb 2004; Hodgkinson 2009), exemplified by the 10 tonne nail-hoard found at Inchtuthill in Perthshire, Scotland (Angus et al. 1962) may have led to the importation of iron to Ireland through trade and/or raiding. Certainly, Strabo reported iron as one of the exports from southern Britain as early as the first century BC (Strabo 1923, 255).

The Adoption of Iron Technology

The precise origins of the earliest iron technology in Ireland are not known. However, the knowledge of how to smelt was almost certainly brought to the island and the earliest smiths and smelters must have been either foreigners or returned émigrés. In this context, the connection between the case-study region and the Arras culture of Yorkshire implied by the bronze box from Ballydavis, the location of some of the earliest iron smelting in Ireland, is very interesting. Halkon (2007; 2008) has pointed out the importance of iron technology in Yorkshire in the first millennium BC, suggesting the smelting technology in use may have developed from cultural contacts with France. This was a technology reliant on bog ore (Halkon 2007), and while it was on a larger scale than Irish iron smelting, the hints of a connection between the study region, Yorkshire and ultimately northern France provide a tantalising hint of a possible route for the introduction of smelting technology to Ireland.

The earliest production of iron appears, on current evidence, to have taken place within the case-study region, probably by the sixth century BC. This is substantially later – by as much as three centuries – than the first attested iron production in southern England and mainland Europe (Collard et al. 2006). Technological innovations exist primarily as human thoughts, spread between individuals and groups but they will only be adopted if they can fit within existing values and traditions, regardless of their technical superiority (Hjärthner-Holdar and Risberg 2009). The delay in the adoption of iron technology in Ireland implies a degree of conservatism in the Irish Late Bronze Age and it is unlikely that the introduction of iron technology can be seen as a causative factor in the reduction in bronze artefacts visible in the archaeological record. The exact circumstances and causes of the Late Bronze Age ‘collapse’ in Ireland are issues beyond the scope of this study but it would appear that the social climate of
the sixth or seventh century BC in the Irish midlands, was sufficiently dynamic to allow the adoption of iron technology.

It is likely that iron was a prestige material when it was introduced and as such its production and control may have been contested, though the poor archaeological evidence from the early Iron Age in Ireland make a reconstruction of the effects of this very difficult. The production of iron was a complex and highly skilled process (see earlier chapters) and was probably seen as magical, religiously potent and probably dangerous (Budd and Taylor 1995; Haaland 2006; Giles 2007b). The religious significance of the new metal must have been enhanced by its origins in bogs, places which previously had been recipients of metal offerings.

It is unlikely that iron was a utilitarian metal in Ireland prior to the first millennium AD, and possibly as late as the early medieval period when it first became a common material (see Chapters 5 and 6; Scott 1990). That it was clearly seen as a prestige metal can be seen in the production of iron versions of many high-status metalwork items, such as horse gear, fibulae, mirrors, and cauldrons, also produced in bronze (Raftery 1983). Other items made from iron, commonly seen as more functional, such as swords, knives, axes, sickles, shears and needles were probably also expensive, symbolically charged prestige items in the Iron Age. That iron was an appropriate material for use in religious ritual is demonstrated by the bronze box, mentioned above, from Ballydavis which included an iron mount on its lid decorated with red enamel (Keeley 1996a; 1996b; 1999).

**Isolated, Small-Scale Smelting**

The concentration of smelting sites in the study region includes fourteen sites with definite evidence for smelting (Table 7.2), four with possible/indeterminate evidence and one, Ardan 3, Co. Offaly (IID:006), which produced waste slag but no evidence for *in situ* smelting or smithing (Clark and Janes 2008a). The quantity of smelting sites identified is in stark contrast to the number of smithing sites identified (see below), and their distribution in the landscape is also very different. These sites represent a significant proportion (73%; 61) of the late prehistoric furnaces identified in Ireland (83; see Features Gazeteer, Appendix 5), with a large number of them (40) coming from one site, Derrinsallagh 4, Co. Laois (IID:077; Lennon 2009c).

There is a consistency in terms of the layout, scale and technology of smelting in the study region that is striking. Smelting sites were generally isolated from other activity on one-off sites that probably indicate individual short-term smelting episodes. However, there were
exceptions to this general pattern. Derrinsallagh 4, Co. Laois (IID:077) represents an extraordinary site which saw significant, probably seasonal, smelting over a comparatively long period, possibly measured in decades. This would have been an important location in the contemporary landscape, synonymous with iron production. Ballydavis, also in Co. Laois may also have been a special site; it is unusual in having evidence for both smelting and secondary smithing, but also for the association of the iron smelting activity with a ritual landscape, and a possible settlement.

Characterising Smelting in the Landscape

The majority of smelting sites were small in scale comprising single, paired or small groups of furnaces. Only two sites: Monganstown, Co. Westmeath (IID:154) and Derrinsallagh 4, Co. Laois (IID:077) had larger groups of furnaces. Monganstown had evidence for five furnaces grouped together in an area c. 5m$^2$, with a number of associated features including pits, a stakehole, a posthole and a charcoal kiln, not all of which were contemporary (Lehane 2009); the evidence from Derrinsallagh 4 is discussed below.

Evidence for other activities on the other smelting sites is variable but generally not very significant or not clearly contemporary. For example, at Rossan 6, Co. Meath (IID:179) the single definite furnace had a small number of pits in close proximity which may also have related to ironworking activity but pits, spreads furrows and a field boundary located elsewhere on site are not clearly associated with them (Murphy 2004c). At Moyally 2, Co. Offaly (IID:157) two furnaces were identified side by side with one other feature, a sub-rectangular pit, probably also associated with ironworking (Bayley 2007a). Two furnaces from Cherryville Site 12, Co. Kildare (IID:052) were unusual in that they were located approximately 20m apart, other associated pits on the site might also be furnace bases (Breen 2005; Young 2005e).

These smelting sites, judging by the quantities of slag associated with them (Table 7.3), were not producing iron on a large scale. Extensive experimental work in Wales, based on non-slag tapping Iron Age furnaces smelting bog ore, similar to Irish furnaces, produced an average of 5kg of slag and 2 kg of bloom from 8kg of ore (Crew and Charlton 2007, 222). The quantities of slag per furnace from smelting sites in the study area is often much lower and generally not substantially higher than this (Table 7.3). To give some context to the quantities involved, two prehistoric smelting sites excavated in Wales which were worked over a number of years at Bryn y Castel and Crawcwlte West produced 1.2 and 6 tonnes of slag respectively (Crew 1987;
While a potentially similar iron smelting technology in Iron Age Yorkshire resulted in the deposition of slag dumps weighing as much as 5 tonnes (Halkon 1995; 1997; 2007).

What this means is that individual furnaces were only producing small quantities of iron, probably a few kilogrammes. Some sites such as Monganstown, Co. Westmeath (IID:154), and possibly also Bushfield 1, Co. Laois (IID:034), saw slightly more intensive activity, producing 61kg and 80kg of slag respectively. These represent a slightly higher intensity of production but still single episodes of smelting, probably measuring in weeks. Most of the sites in the study area represent discrete events aimed at producing limited quantities of iron over even shorter periods (days or weeks). The working of multiple furnaces on such sites might indicate some time pressure and it is likely that smelting was seasonal, fitting into the peripatetic, pastoral lifestyle of the Iron Age in the study region. Other tasks, including the gathering of ore and the preparation of charcoal could have been undertaken separately.

Some of the Irish sites have very small quantities of slag, less than 1kg per furnace, and this requires some explanation. The most obvious is that slag was being disposed of off-site or was not collected in the field. However, the very small quantities of slag from many sites could suggest Irish smelting techniques (e.g. the recycling of slag) and ores produced very small quantities of slag. Significant analytical and experimental work is required to find a definitive answer, but overall the small amounts of slag confirm the small-scale and short-lived character of smelting sites in the case-study area.

**Exceptional Sites**

Two of the smelting sites in the case-study region: Derrinsallagh 4 (IID:077) and Ballydavis (IID:020-022), both in Co. Laois, and possibly contemporary, stand out as exceptional in the context of the smelting sites already discussed.

**Derrinsallagh 4**

A re-assessment of the Derrinsallagh 4 site for this study identified 40 definite furnaces (see Chapter 5) but this should be viewed as a minimum figure; possible furnaces were also identified and more may lie outside the excavated area. The site also produced substantially more slag (296kg; Photos-Jones and Wilson 2007a; Lennon 2009c) than any other smelting site identified in this study (Iron Age or early medieval). This represents 7.4kg per identified furnace, broadly in line with the amount of slag produced by other furnaces from the study area (Table 7.3).
Unfortunately, the nature of Derrinsallagh 4, with a large number of stratigraphically isolated groups of furnaces and other features, means the three radiocarbon dates available from the ironworking phase (Fig. 7.10) do not date the duration of the site with any certainty (Lennon 2009c). The clustering of furnaces from the site into small groups of between one and four furnaces was noted in Chapter 5. Approximately 17 spatially distinct furnace groups can be identified on the plan (Fig. 7.11). The parallels between these individual groups and other, isolated, smelting sites discussed above suggest each cluster represents a discrete period of iron smelting.

The evidence from the site could be read in a number of ways but if smelting was carried out annually then the furnace clusters could represent as much as two decades of activity. This would be shorter if clusters were worked in parallel, perhaps by different kin groups (possibly indicated by variations in furnace design; see Chapter 5). Alternatively, all of the furnaces on the site could have been worked simultaneously over a very short period. This seems unlikely considering the subtle variation in furnace designs across the site, which might be expected to be more uniform if constructed at the same time. The duration of the site could also relate to the availability of ore or fuel. It may represent the annual working of a rich ore source to exhaustion over two decades. Tylecote (1986, 125) suggested bog ore could regenerate at a rate of 5-10cm a year but this may not have been enough to sustain smelting at Derrinsallagh 4. The possibility also exists that smelting at the site took place at much longer intervals, indicating site use over many decades.

What is abundantly clear is that Derrinsallagh 4 was an exceptional site, most likely worked over a number of years. The only other Iron Age ‘places’ known to have been persistently returned to are large communal ritual sites and a few places of votive deposition such as the river Shannon or Lisnacrogher, Co. Antrim (Raftery 1994). This was a place which must have been synonymous with smelters and smelting and access to the site may have been an important element of the creation of their identity.

**Ballydavis**

The smelting at Ballydavis has already been discussed in terms of very early evidence for iron production in Ireland. The three excavated sites from the Ballydavis complex, Ballydavis 1 (IID:020), 2 (IID:021) and 3 (IID:022) had varying evidence for iron production. No specialist analysis is available for Ballydavis 1 and while furnaces were reported (Keeley 1996a; 1996b; 1999), no further details are available. The bronze box with parallels in Yorkshire was found in a cremation burial on this site.
Ballydavis 2 (IID:021) was excavated by Fegan (2006) but remains unpublished. However, some specialist analysis of ironworking from the site has been undertaken (Young 2005d) and some information regarding the site was included in McGarry’s (2008a) study of Irish Iron Age burials. The site consisted of a large hilltop enclosure over 100m in diameter. Within the enclosure, which was partially excavated, the remains of three ring-ditches were found along with a number of burials, postholes and pits. Just outside the enclosure a group of postholes may represent two circular structures, potentially the remains of settlement, and postholes within one of the ring ditches might indicate a roundhouse closely associated with burials (McGarry 2008a, 35). Finds included Late Bronze Age pottery, a copper alloy fibula with silver inlay, a bronze bead or spacer, a coil of copper alloy wire, two riveted copper alloy sheets, a barbed and tanged arrowhead, a glass bracelet, a possible stone pendant, a large iron pin and other ferrous artefacts.

Ballydavis 3 (IID:022), excavated by Ó’Maoldúin (2006; 2010), was situated close to Ballydavis 2, outside the large enclosure. The site produced a pair of smelting furnaces and a number of pits, including one partially surrounded by a slot trench. A number of similar but undated furnaces and other evidence for both smelting and smithing were found in the nearby townlands of Cappakeel, Morett and Jamestown (Cotter 2004; Fairburn 2004; Dempsey 2005; Ó’Maoldúin 2005; Young 2005d). These townlands are all clustered in close proximity, to the northwest of Ballydavis, close to the Greath Heath of Co. Laois which preserves a ritual landscape probably associated with the Ballydavis complex (Feehan 2002). It is likely that at least some of these sites are Iron Age in date.

The significance of the Ballydavis complex lies in the association of ironworking, and particularly smelting, with a very significant ritual landscape akin to that at Knockaulin/The Curragh (see above). Smelting sites in the study region were generally isolated from any other activity and the exception at Ballydavis requires some explanation. The lack of clear information from the site is a problem but the early date from smelting at Ballydavis 3 (IID:022) might suggest the very earliest smelting sites were associated directly with communal ritual sites (see discussion below).

Smelters and Society

In general, with the exception of Ballydavis, smelting sites in the study region appear to have been the product of a seasonal or annual approach to smelting in isolated locations in the landscape. Many sites saw one-off use, though Derrinsallagh 4, Co. Laois (IID:077) seems to
have been returned to repeatedly over many years. The practice of smelting, even at Derrinsallagh 4 was small-scale and would have produced only limited quantities of iron, particularly when compared with the scale of smelting in Britain during the Iron Age (Cleere and Crossley 1985b; Crew 1985; 1987; 1989a; 1989b; Halkon 1995; 1997; 2007; Hodgkinson 2009).

The small scale of iron production supports the idea that iron was not a particularly common or mundane material in the Irish Iron Age, an idea supported by the general lack of iron finds from the period (Raftery 1994). If iron production was limited this might suggest that the knowledge required to smelt it was not commonly available. Members of society with access to such knowledge would therefore have been seen as different and possibly powerful or dangerous (Giles 2007b). The isolated location of smelting could be seen as an attempt to restrict knowledge. In contrast to smithing (see below) smelting was carried out away from prying eyes. This might also indicate there was an element of danger or taboo associated with it (cf. Haaland 2004; Haaland 2006).

Alternatively, the demand for iron may have been relatively small and the small scale of smelting may not relate to societal restrictions. Smelting sites could represent ad-hoc production based on immediate need. There is also the possibility that iron was also imported; Strabo reported iron as one of the exports from southern Britain in the first century BC (Strabo 1923, 255). However, the lack of smithing evidence from the Iron Age and its association with particular, ritually significant, locations (see below) argues against this interpretation. If iron supply was uncontested and readily available, even through import, then smithing sites would be far more ubiquitous and less restricted in their distribution. For example, in southern Britain, where iron was commonly used and worked through the Iron Age by most sections of society, evidence for smithing was found throughout the landscape, with evidence for smelting restricted to particular locations (Ehrenreich 1991b).

**A Place for Smithing, A Place for Smelting**

While smelting requires some skill, once the necessary knowledge has been obtained and the appropriate ingredients gathered, it is relatively straightforward to produce a bloom, as demonstrated by the many experimental blooms produced by relatively unskilled archaeologists. However, the skills involved in secondary smithing, the production of finished iron objects, are far more diverse, from simple hammering of hot metal, mastered in a relatively short amount of time, to far more difficult tasks such as forge welding and heat
treatment requiring years of experience to perfect (Scott 1990, 21-26). This skilled crafting, the ability to transform iron into desirable, aesthetically pleasing and symbolically charged objects may also have been an expression of supernatural abilities (Spielmann 2002; Giles 2007b).

It is not clear if there was a distinction in the Iron Age between those who smelted iron and those who worked it, but the dissimilarity in the location of the two processes in the landscape might suggest this. However, the admittedly limited, historical evidence for the existence of a pre-Christian smith-God in Ireland (Gillies 1981) with no mention of a smelting deity suggests both roles were incorporated in the work of one ironworking deity. As we have seen, iron smelting was largely an isolated occupation, carried out, as far as it is possible to tell, away from settlement and other activities. In contrast, the evidence from the case-study region suggests smithing took place in places of communal gathering and ritual.

### Smithing on Hilltop Sites

Only four sites in the case study region had definite evidence for smithing, all of which also had evidence for smelting (Table 7.1). One other smithing site, Knockaulin, Co. Kildare (Johnston and Wailes 2007) is known from the study area but was identified too late for inclusion in the project database (Table 4.5). The number of Iron Age sites throughout the country with clear evidence for smithing is quite low and this is reflected in their limited distribution (Fig. 7.1). It is not clear why so few smithing sites have been identified from the period. Indeed, it might be expected that smithing rather than smelting evidence would be more widespread and common if iron was being routinely used throughout the country (as was the case in southern Britain e.g. Ehrenreich 1991b; 1995). It is particularly perplexing given the wider distribution of smelting sites. It seems a strong possibility that the types of locations where smithing was undertaken are not the same as those areas where archaeological excavation has tended to take place.

Evidence for smithing on some of the sites in the study was very tentative. Primary smithing was identified at Monganstown, Co. Meath based on the identification of one small SHC (Fairburn 2006), though subsequent microscopic and chemical analysis of potential smithing slag from the site identified only non-tapped smelting slag (Martinón-Torres 2009). The specialist report from Newtown 1 is not available, while Cherryville Site 12 had limited evidence for smithing in the form of a fragment of one SHC and some ambiguous slag residues (Young 2005e).
Only two sites, Ballydavis 2, Co. Laois (IID:021) and Knockaulin, Co. Kildare, had solid evidence for secondary smithing. Ballydavis 2 produced a small amount of slag but there was good evidence for secondary smithing in the form of smithing floor fragments and hammerscale (Young 2005d). This evidence came from within the large hilltop enclosure on the site, which enclosed a number of burials and ring ditches. The smithing may be related to smelting nearby at Ballydavis 3 (Young 2005d; Ó'Maoldúin 2010), though the date of all of the ironworking debris is not known. Knockaulin produced just over one kilogram of probable secondary smithing slag dating to the Iron Age from the summit of the hill, inside the ritual enclosure (Hamilton 2007; Johnston and Wailes 2007). The slag was found strewn around the excavated area (Fig. 7.12) and was associated with a number of phases dating between the first century BC and the first century AD (Johnston 2007a).

The Social Role of Smiths

The evidence for smithing in the study area is very restricted but the character of the two clearest sites, communal ritual sites located in hilltop enclosures associated with burial landscapes, suggests very particular sites were considered appropriate places for smithing in the Iron Age. This might explain the lack of smithing sites identified in this study: hilltop locations with clear evidence for prehistoric burial and ritual are not the sorts of landscapes subject to development in modern Ireland.

Other Hilltop Sites

Very significantly, this association between important communal hilltop sites and secondary smithing can be traced elsewhere in Iron Age Ireland. Secondary smithing in combination with non-ferrous metallurgy within a workshop or smithy dating between the fourth and second centuries BC has been demonstrated on the Hill of Tara, Co. Meath (IID:188; Crew and Rehren 2002; Roche 2002). The smithing on Tara pre-dated and was cut by the Iron Age enclosure known as Rath na Rí but it may have been enclosed by a large, as yet undated, ditched pit circle identified by geomagnetic survey around Rath na Seanad and Duma na nGiall (Fenwick and Newman 2002; Roche 2002; Fig. 7.13). Some evidence of iron smithing within a large hilltop enclosure was also identified at Mooghaun South, Co. Clare (IID:155), where the activity dated to the centuries spanning the birth of Christ (Grogan 2005a). An isolated smithing hearth from Rathgall Hillfort, Co. Wicklow (IID:171; Scott 1990; Raftery 1994; Rehren 2007), dated between the second century AD and the sixth century AD., could have been broadly contemporary with Mooghaun.
Early medieval historical sources give a view of a society where skilled blacksmiths were highly valued members of society, sometimes feared for their supernatural abilities (see Chapter 8; Gillies 1981; Scott 1990). It seems likely, based on evidence gathered for this study, that the early medieval regard for smiths was founded on similar Iron Age beliefs. The later hilltop enclosures of Freestone Hill, Co. Kilkenny (IID:099; Raftery 1969) dated by Ó’Floinn (2000, 21) to the fourth or fifth centuries AD and Clogher, Co. Tyrone (IID:055; Warner 2000; Warner 2009) dated to the fifth or sixth centuries AD seem similar in character to the earlier examples discussed above. The practice of smithing on these later hilltop sites may represent a persistent view of these sorts of locations as appropriate places to create iron objects.

The Smith as Ritual Specialist

The production of iron blooms in isolated locations, prior to their transportation to central sites of communal ritual for smithing, suggests a significant degree of control of the production and use of iron by a section of society. The lack of evidence for any centralised hierarchical authority suggests this was not a central political authority. An alternative explanation can be sought in the symbolic and religious role of iron and of smiths. It is likely that the large ritual gatherings associated with hilltop sites in the Iron Age were seen as the appropriate venues for smithing, probably as an integral part of ritual activities. It was not normal, whether through taboo, coercion or convention to produce iron objects away from these places. This suggests that smiths themselves were important ritual practitioners at these gatherings, using their craft-skills and control over iron to create identities imbued with magical power and authority.

The symbolic importance of iron in Iron Age Europe has been discussed by a number of scholars (e.g. Hingley 1990; 1997; Aldhouse-Green 2002; Hingley 2005; Haaland 2006; Hingley 2006; Giles 2007b) and it may have been associated with concepts of transformation, regeneration and the agricultural cycle. Johnston (2007c) saw the smithing on Knockaulin, in combination with other evidence for the possible manufacture of glass, non-ferrous metallurgy and bone-working, as being an element in ‘economic rituals’ on the site; an entrepreneurial attempt to take advantage of communal gatherings on the hill. While large numbers of people gathered in one place may have provided a ‘market’, a view of smiths in this context as opportunistic entrepreneurs seems inappropriate. The fact that secondary smithing is focused entirely on hilltop sites in the study area suggests they are significant in other ways.

A more appropriate understanding of the phenomenon of smithing at places of communal ritual is to see it as indicating a special role for iron specialists in Iron Age society and ritual. Craftspeople are not drones providing materials for market but rather dynamic active
participants in the creation of their social roles and identities (Costin 1991; Spielmann 2002). The ‘skilled crafting’ of Iron Age smiths would have been intimately associated with their social power, authority and prestige (Giles 2007b). The nature of the evidence from Iron Age Ireland suggests that this relationship was heightened by the performance of smithing in locations where large groups of people were gathering at significant times of the year. It is a short step to infer the active participation of smiths as religious specialists in communal ritual. Iron objects and even iron slag may have been seen as powerful objects actively used in religious ceremonies (Hingley 1997, 15). The dispersal of iron slag around the ritual focus of activity at the summit of Knockaulin, Co. Kildare (Fig. 7.13) might have resulted from such activities, indeed the importance of iron to ritual on the site is suggested by the deposition of an iron sword in one of the ditches on the site (Johnston 2007b).

Summary

The archaeology of Iron Age Ireland is very different in many respects from other periods in Irish archaeology, dominated by evidence for ‘non-routine’ activities: votive deposition, linear earthworks and ‘royal sites’. The evidence for iron production collected for this study has provided an unprecedented opportunity to approach the Iron Age from an entirely new perspective: focusing on new site types (smelting and smithing sites) and evidence for craft production previously unknown from the period. This chapter has focused on a case-study region in the midlands, an area which was a focus for smelting in the Iron Age, probably from as early as the sixth century BC. A re-assessment of the archaeological evidence in the area suggests iron production was taking place in the context of a mobile, pastoral society living in archaeologically invisible settlements and making very few permanent marks in the landscape.

The two stages of iron production: smelting and smithing took place in different places in this landscape. They were probably carried out by the same iron specialists who worked seasonally, integrating the practical demands of iron production into the agricultural cycle. Smelting sites were often isolated and always small-scale, producing a small amount of iron for a society where it seems to have been regarded as a prestige metal rich in symbolic meaning. The symbolic and religious importance of iron can be demonstrated in the archaeological record through its association with a number of exceptional sites.

At Derrinsallagh 4, Co. Laois (IID:077) smelting was carried out repeatedly, possibly annually, over a period as long as two decades. The site, with its visible remains of old smelting campaigns would have been exceptional in the Iron Age landscape, one of the few places in

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the landscape, alongside burial monuments, hilltop enclosures and linear earthworks, with visible evidence for the persistent re-use of the landscape by humans over long periods. The site would have been directly associated with iron producers and access to the site and involvement in smelting may have played an important role in the creation and maintenance of the identities of the smelters who worked there.

Two ritual landscapes with hilltop enclosures and associated burial monuments at Ballydavis, Co. Laois and Knockaulin, Co. Kildare demonstrate a special relationship between the production of iron and Iron Age ritual. It is to sites like these that smelted iron blooms were brought to be worked into desirable objects, probably as part of communal rituals. This practice can be paralleled in the use of other hilltop sites for the working of iron, particularly at Tara, Co. Meath (IID:188). The skilled smiths practicing their craft at these special hilltop locations seem to have had a dual role as ritual specialists and craft workers, and it is possible that iron and iron slag may have played a direct part in communal ritual, particularly at Knockaulin and Tara. The ritual and symbolic importance of iron suggests a smith-deity may have been important in the religion of the Leinster region in the Iron Age and it is notable in this context that no iron slag was recovered from excavations at another ‘royal site’ at Navan, Co. Armagh (Waterman 1997), in a region with little evidence for Iron Age smelting (Fig. 7.1).

This review of the unprecedented new corpus of material for the Irish Iron Age represented by the ironworking sites identified in this study has attempted to provide a glimpse of a more ‘routine’ part of Iron Age life. A little unexpectedly, it has demonstrated the central role iron technology and iron production may have had in the ritual and symbolic lives of the inhabitants of the study region in the Iron Age. Intriguingly, the place of iron and ironworkers in society, and society itself, in the early medieval period (discussed in Chapter 8) is very different, indicating some significant changes in the understanding and use of iron, probably at the end of the Iron Age in the fourth or fifth centuries AD.
8. SMITH AND SMELTER: SPECIALISTS IN EARLY MEDIEVAL IRELAND?

In contrast to the Iron Age, there is a rich array of archaeological and historical evidence for life in early medieval Ireland (e.g. Kelly 1988; Edwards 1990; Mytum 1992; Kelly 1997; Charles-Edwards 2005; Edwards 2005; Ó’Cróinín 2005b; Laing 2006; O’Sullivan and Harney 2008b; Ó Bhrolcháin 2009; Corlett and Potterton 2010; O’Sullivan et al. 2010a; 2010b; O’Sullivan and Nicholl 2010; Corlett and Potterton 2011). The period saw a massive increase in the availability and ubiquity of iron objects (Mytum 1992, 229), and a parallel change in perceptions of iron technology and iron producers. The richness of the surviving record is reflected in the number of ironworking sites (153, 76%) in this study with dates spanning the period. These sites were spread across the country (Fig. 8.1) and vary significantly in terms of their functions and scale. The archaeological evidence for iron production they produced, reassessed in chapters five and six, represent an exceptional record of an early medieval craft industry (see Comber 2008 for a review of other crafts from the period). The diversity of the evidence, including a small number of smelting sites, as well as smithing sites of all types and scales, provide an unprecedented opportunity to understand the organisation of iron production and its place in early medieval social lives.

Significantly, a small number of sites in this study revealed evidence for iron production on a very large scale, previously unknown from early medieval Ireland. These sites strongly imply the existence of specialist ironworkers in the period, people who derived much of their identity as well as their wealth, authority and status from their skill with hammer, tongs and anvil. This chapter focuses on understanding the place of these specialists, defined by their association with iron, in early medieval society. This is achieved through a detailed consideration of the archaeological evidence for both specialist and non-specialist ironworkers, culminating in a chronological and contextual account of iron production in early medieval Ireland.
Identifying Specialists

Craft specialisation was discussed in Chapter 1, where it was defined, very simply, as the production of items in volumes in excess of individual/group needs. However, identifying specialist ironworkers in the archaeological record is not always straightforward. The number of items made need not have been particularly large, though in some cases they certainly were. A small number of archaeological indicators from sites are taken here as suggestive of the work of specialist iron producers.

- A focus on the working of iron rather than non-ferrous metals, where both are present.
- Large quantities of iron slag deposited over short periods of time.
- Dedicated, substantial ironworking areas/structures with evidence for constant or recurring work.
- Evidence for a focus on the production of one, or a small range of object types.
- Historical evidence for an association with iron production.

A key difference is drawn here between specialist sites and evidence for specialist ironworking. A specialist site, while dedicated to iron production, may not necessarily have been used by a specialist. For example, an isolated smelting furnace or smithing hearth, technically a specialist site, might indicate small-scale, ad-hoc work for personal use by any (specialist or non-specialist) member of society with sufficient knowledge.

Many sites in this study produced evidence for some but not all of the indicators described above. These are discussed in detail below but in some cases it is not possible to interpret the activity represented on a site with any confidence. There was a spectrum of practice in the early medieval period, rather than a polar opposition between specialists and amateurs, and the archaeological record reflects this.

Historical Evidence

The surviving literature from early medieval Ireland comes in a variety of forms including law tracts, Saint’s Lives, annals, prayers, sagas and poetry (Kelly 1988; 1997; Ní Bhrolcháin 2009). However, the information contained in these sources must be treated with some care; each was written for a particular purpose and they have been copied, and possibly altered, by multiple scholars at different times since their composition. For example, the old Irish law tracts which originated in the 7th-9th centuries AD often survive in much later (12th-16th century
AD) manuscripts (Kelly 1997, 7). The glosses or explanatory notes that accompany these texts can be significantly younger and written in very different social contexts to the text they explain (Kelly 1997, 11-12; Comber 2008, 13).

The historical literature relating to iron has been thoroughly reviewed by Scott (1981a; 1982; 1983a; 1983b; 1987; 1988; 1989a; 1990, 171-212) and other scholars (e.g. Gillies 1981; Comber 1998; 2004, 11-16; 2008, 13-23). What they have shown is the significant status, and even supernatural power, accorded the specialist iron smith in early medieval society. This was an intensely hierarchical society, divided between the free and un-free, with a subset of the free belonging to the privileged or 'nemed' noble class (Gillies 1981; Kelly 1988; 1997). Individuals were accorded ‘honour prices’ relating to their rank in society, payable if a major offence was committed against them, with smiths commanding prices second only to the master wright (builder/carpenter) in the ranks of craftspeople (Gillies 1981, 75-76; Kelly 1988, 62-63). A number of law tracts count smiths as belonging to the lowest level of the nemed class, though they did not enjoy all of its privileges (Kelly 1988, 10).

Unlike the wright, some sources hint at an association between blacksmiths and the supernatural (Comber 2008, 21). For example, a 7th century prayer asks for protection against the spells of druids, women and blacksmiths and the 9th century Triads link the blacksmith’s forge, anvil and punch with supernatural mythological figures, possibly derived from older pagan deities (Scott 1990, 186). Perhaps because of their perceived power, blacksmiths were held in particular esteem, with a smith in the saga Táin Bó Cúailnge worthy of entertaining a king (Comber 2008, 20). Smithing was also considered a respectable craft for saints and their ancestors, even for Joseph, the father of Jesus (Gillies 1981, 76; Scott 1990, 185; Comber 2008, 21). Linked to this may be the metaphorical association of blacksmiths, particularly through their anvils, with strength, masculinity and honour (Scott 1990, 187-188).

The supernatural gifts of the smith may derive from previous pagan belief (Gillies 1981). There is good evidence from early medieval texts for a pre-Christian smith-deity, Gobann or Gobniu (Gillies 1981; Scott 1990). Other mythological figures associated with smithing include Sitchenn, the smith of Tara who was both a prophet and proficient in the occult arts (Scott 1990, 185-186). The pagan goddess Brigit, very possibly related to the Christian saint of the same name (Cusack 2007), was associated with poetry, healing and smithing (Ó’Cróinín 2005a, 464). Interestingly, Brigit the saint was primarily associated with the monastery of Kildare, only c. 10km to the northwest of Knockaulin and even closer to the associated ritual landscape of the Curragh. It is noteworthy in this context that two Iron Age ritual sites (Tara and Knockaulin)
with archaeological evidence for smithing in the Iron Age (see Chapter 7) had early medieval associations with supernatural smiths.

Previous Approaches

The identification of specialist ironworkers and the organisation of iron production in the early medieval period in Ireland have a long history, largely prompted by references to blacksmiths in the historical sources discussed above (Gillies 1981, 77; Scott 1990, 99-102; Mytum 1992, 229-235; Edwards 2005, 284; Carlin et al. 2008b, 105-112; Comber 2008, 120-124; O’Sullivan et al. 2010a, 111-115). A number of perspectives have been put forward. Scott (1990, 99-102) – with a strong caveat based on the limited evidence he had to work with – posited five levels of iron production and consumption, with two involved in the production of blooms and three relating to secondary smithing. He argued for the existence of specialist smelters as well as smiths.

Mytum (1992, 234), drawing from the historical literature, proposed a centralised system with highly specialised master-smiths attached to individual tuaths (small kingdoms) and patronised by local kings. In this model smithing was carried out primarily in a centralised settlement with the small amounts of slag found on many sites related to the visits of partly-itinerant specialist smiths. Carlin et al. (2008b, 110-112) drew more heavily on archaeological excavations, particularly from the M4 motorway scheme. They disagreed with Mytum, seeing smithing knowledge as far more dispersed, with non-specialist ‘farmer-smiths’ being largely self-sufficient, smelting and smithing iron objects for their own needs, with some specialisation on high-status secular and ecclesiastical sites.

More recently Comber (2008, 120-124) saw local nobles controlling the production and supply of iron through a specialist ‘master-smith’ in return for the provision of materials and subsistence. In this view, the master-smith exercised power over other subsidiary smiths in a Tuath through the control of iron stock. She saw evidence, particularly the site of Cahircalla More, Co. Clare (IIID:038), in the archaeological record for some smiths having their own enclosed settlements, with others living ‘nomadic’ lives. Comber (2008, 122; following Scott 1990, 100) also saw evidence for the existence of specialist smelters in historical references to the Na Cuirc people providing large quantities of blooms as tribute to the Connacht Kings.

These approaches have necessarily simplified what was probably a far more complex situation. The archaeological evidence collected in this study (detailed below) provides evidence for a diverse range of site types and scales of working, some of which do not fit into a simple
scheme of specialist master smiths vs non-specialist farmer smiths. There was almost certainly a wider spectrum of practice, from very basic cold hammering of a bent tool to the skilled production of large iron objects such as the bells from Clonfad, Co. Westmeath (IID:058; Stevens 2009; Stevens 2010). Some smiths were certainly high-status, wealthy and respected members of society but others were members of the clergy, lowly apprentices, labourers, journey men and/or farmers.

**Specialist Smithing Sites**

There is excellent evidence from a small number of sites in this study, dating to the early medieval period, for blacksmithing on a large-scale on both secular and church sites in the early medieval period. These sites have evidence for sustained working over significant periods with associated slag measured in hundreds of kilogrammes and were almost certainly producing iron objects for trade, exchange or tribute. Without analysis of artefacts from a site, the level of blacksmithing skills involved are unclear but evidence for the manufacture of large brazed iron bells at Clonfad, Co. Westmeath (IID:058; Stevens 2009; Stevens 2010) gives an indication of the proficiency of at least some of these smiths.

Specialist working on this scale would have required considerable amounts of iron and fuel and the smithies would not have been single-person operations. The law tracts give some indication of this, with references to bellows-blowers, multiple hammer strikers as well as onlookers and domestic animals liable to get injured if they stray too close (Scott 1983a; 1990, 189-197). Many others would have been involved in the production of charcoal, the smelting of iron and the transportation and trade of these important materials. The specialist smith(s) would have been at the centre of a web of family, retainers, patrons, visitors, clergy, traders, apprentices, labourers and slaves.

It is not clear if the smiths working on ecclesiastical sites were monks themselves. A seventh century reference in Adomnán’s Life of St Columba (Sharpe 1995, 178) to monks on Iona ‘who knew the blacksmith’s craft’ suggests smithing on at least some ecclesiastical sites may not have been the preserve of the lay community. At the same time it is possible that highly specialised smithing on sites such as Clonfad, Co. Westmeath (IID:058; Stevens 2009; Stevens 2010) might indicate the employment of skilled lay-smiths not distracted by the duties of the religious life. In either case the smiths were almost certainly resident, and probably full-time, craftworkers.
In contrast, the specialist smithing evident on enclosed settlements (see below) may indicate these sites were the residences of high-status smiths similar to those described in the early medieval literature (see above). In most respects these were ordinary farming settlements, probably the residences of landed smiths who derived their status, authority and a large part of their identity from their craft skills, while at the same time sustaining their family and retinue through the usual agricultural and domestic practices found on many early medieval settlements (e.g. O’Sullivan and Nicholl 2010).

A number of other settlement sites had significant, though apparently smaller-scale, evidence for smithing in association with non-ferrous pyrotechnical industries such as bronze-working, glass-working and enamelling (discussed below). It is not clear to what extent the ironworking on these sites represent the work of specialist smiths. It may be that specialist smithing was carried out on the sites for short periods, possibly by a visiting craftsman. Alternatively, they may represent evidence for craftsmen skilled in multiple media; for example a bronze smith might have been capable of making or repairing his own iron tools. They may also indicate a group of craftspeople working under a patron, possibly for a limited time.

Settlements

Lowpark

The most significant and large-scale specialist settlement site identified in this study is Lowpark, Co. Mayo (IIID:148) where 1372kg of slag was recovered and analysed (Gillespie 2008; Wallace 2008; Gillespie 2010). The site appears to have been the residence of a specialist smith and his retinue, producing iron artefacts on a routine basis. It had a number of sunken smithy buildings and hearths which demonstrate extensive smithing over a considerable amount of time and from the earliest phases of the site (Gillespie 2010; see discussion in Chapter 6). This smithing activity took place in a context with evidence for enclosure, souterrains and buildings, indicative of a typical early medieval settlement. The obvious conclusion to draw is that this site was the home of a smith and his – most likely not her (cf. Scott 1990, 184-188) – family, apprentices, workers and slaves.

The evidence for multiple phases of ironworking in different buildings suggests the working of iron over a significant period, probably as a full-time occupation in combination with the normal work involved in crop and animal husbandry. It is not clear exactly what was being produced at Lowpark but iron knives, buckles, shears and nails were excavated (Carroll and Quinn 2008). The finds from the site do not represent the total output of the on-site smithing,
even taking preservation issues into account, and it is very likely that the site was producing objects for trade or tribute. A gold filigree panel from the site was interpreted by the excavator as ‘ready for re-use’ and indicative of gold-working on site, either a resident or an itinerant goldsmith (Gillespie 2010, 297). Considering the lack of other evidence for non-ferrous metalworking, the item could be better interpreted as portable wealth rather than raw material for manufacture. Either way, such a valuable item suggests the presence of a high-status/wealthy person on the site at some point.

**Lisanisk**

A potential parallel to the smith’s settlement at Lowpark is the settlement enclosure at Lisanisk 2, Co. Monaghan (IID:139) where 850kg of slag was concentrated in two industrial areas on a site with two enclosure ditches and evidence for a central circular structure (Photos-Jones *et al.* 2007; Coughlan 2010). The ironworking at Lisanisk 2 may have been shorter-lived than that at Lowpark and it was not present from the earliest phase of the site: both of the ironworking areas were cut into the earlier, silted up enclosure ditch (Coughlan 2010). Nonetheless, the two phases of ironworking represented by the two industrial areas indicate prolonged periods of smithing within purpose-built buildings, possibly similar in concept to those at Lowpark (see discussion of these buildings in Chapter 6). The phasing of the site, with the ironworking probably associated with the second, larger enclosure, may indicate a change in ownership/occupation. The beginning of smithing operations probably coincided with the arrival of a, presumably resident, specialist smith, possibly displacing the previous resident. The site is very close to a probable early medieval crannog in Lisanisk Lake and this may have been one of the sites for which it produced iron objects.

**Lisleagh**

One other site, Lisleagh 1, Co. Cork (IID:141; Monk 1983; 1984; 1985; 1988; 1995), seems likely to represent the residence of a specialist smith. It produced between 800kg and a tonne of slag (Monk 1988, 60; Scott 1990, 160), preliminarily assessed by Cherubini (2005). The site awaits full publication and analysis but the substantial slag assemblage, possible central smithy, anvil stone and large slag dump in the enclosing ditch suggests large-scale smithing (and possibly smelting) activity. The ringfort was clearly associated with settlement and agriculture and, in an interesting parallel with Lisanisk 2, Co. Monaghan (IID:139) appears to have been enlarged prior to the commencement of ironworking (Monk 1995, 113). The adjacent ringfort, Lisleagh 2 (IID:142; Monk 1990; 1991; 1993; 1994; 1995) was also occupied and produced evidence for ironworking, though on a more limited scale. Clearly the two sites
were associated with, and at some point played host to, a smith and those associated with him.

Ballyvollen
More ambiguous evidence for a possible specialist smithing site associated with domestic activity came from Ballyvollen, Co. Antrim (IID:028; Williams 1985b). The site was identified from a circular cropmark, though no bank or ditch was evident on excavation. Some ephemeral evidence for a structure was found but it is not certain that the site was a settlement. Finds of souterrain ware suggest some domestic activity. The site produced a significant quantity of slag (170kg) which has not been analysed (Williams 1985b, 96), though tuyeres from the site suggest smithing activity. Ballyvollen may represent the poorly preserved remains of a smith’s settlement. However, the ephemeral evidence for settlement and the relatively small size of the slag assemblage make this identification tentative. The site could also represent an isolated smithing site of unknown purpose.

Other Sites

Knowth was not included in this study as the ironworking from the site dated to the tenth or eleventh century AD (Eogan 1977; 2004, 8). Of the other sites, Garryduff 1 is probably the best candidate for a specialist site. The excavations revealed a settlement site with significant amounts of slag strewn across it – including at least 44 ‘furnace bottoms’, probable SHCs – particularly in the area of a number of ironworking features (O’Kelly 1963, 101). The small gold bird ornament found near the entrance to the site is reminiscent of the small piece of gold recovered from Lowpark, Co. Mayo and the situation of Garryduff 1 next to a second enclosure at Garryduff 2 parallels the situation at Lisleagh, also in Co. Cork, though no ironworking evidence was recovered from Garryduff 2 (O’Kelly 1963).

A similar level of ironworking activity may have been present at Lagore where 34 SHCs, including fragments, were reported (Hencken 1950, 231-232), though the presence of possible smithing floors may indicate significant and prolonged smithing, with some of the resulting
slag perhaps being discarded in the adjacent lake. Lagore also played host to significant levels of non-ferrous metallurgy evidenced by very large numbers of crucibles (Hencken 1950; Comber 1997; Comber 2004, 65-92); this co-incidence of ironworking and non-ferrous pyrotechnical industries can also be identified at Garranes (O’Riordáin 1942), and Clogher (Warner 2000), though the scale of ironworking at these sites is less clear. At Clogher, the stone-built hearth and large anvil (cf. Scott 1990, 167) suggest some degree of permanence to the smithing activities on the site but the scale and duration of the activity at Garranes can only be guessed at based on the information currently available.

The level of specialism in terms of iron smithing at Garryduff 1, Lagore, Garranes and Clogher is difficult to judge but they appear to be different in nature from the very large-scale smithing taking place on the smith-settlements at Lowpark, Lisanisk and Lisleagh (discussed above). The location of ironworking alongside non-ferrous industries such as bronze-working, glass-working and enamelling suggests either the co-location of craftspeople with different skills or alternatively craftspeople with many skills. If the former is true then iron slag from the sites may indicate the presence of a specialist smith working, perhaps temporarily, alongside other skilled workers: this level of co-operative living in a status-conscious and hierarchical society might suggest the existence of some kind of patron either living on the site or perhaps owning the site.

This is a situation argued for by Comber (1998; 2004, 14) at Garranes, which she tentatively identified as a royal settlement rather than the dwelling of a craftsperson. Alternatively, the patron need not have been a political figure, one of the craftworkers could have been pre-eminent. A simpler view of such sites may be to see them as settlements owned or controlled by a single craftsperson, similar to the smith-settlements discussed above, working in multiple media and surrounded by a retinue of apprentices, family, workers and slaves. Non-ferrous craftspeople may well have had some skill in blacksmithing. Practically speaking, this would make sense, if only to enable self-sufficiency in the making and repair of tools. The ironworking on such sites could also have been carried out by visiting iron-specialists.

Ecclesiastical Sites

Clonmacnoise

At Clonmacnoise, Co. Offaly (IID:059-063) evidence for large-scale specialist smithing has come from a number of different excavations spread around the site (King 2009). The most significant of these was the excavation of a linear trench between the monastic core and the
River Shannon for a pipeline related to a water treatment facility (King 2004; Young 2005h; King 2006; Anon 2009; King 2009). This produced 271kg of slag and, in combination with the evidence of a slag dump in the river – paralleled at Clonfad, Co. Westmeath (IID:058; Stevens 2009) – as well as slag from other parts of the site, suggests ironworking on a large-scale at Clonmacnoise (Boland 1996; King 2009). The site is unusual in having evidence for both smithing and smelting (discussed separately below). It is likely, given the scale of the ironworking and the strategic trading location of the site on contemporary trade routes (cf. Comber 2001), that at least some of the iron objects produced at Clonmacnoise were made for trade/exchange. However, it is not clear what exactly was being produced.

**Armagh**

Further north, in Ulster, another large monastic centre at Armagh (IID:009-011) has produced similar scattered evidence for ironworking to Clonmacnoise (Gaskell-Brown and Harper 1984; Lynn 1988b; Lynn 1988c; Crothers 1999; Hurl 2003; O’Sullivan et al. 2010b, 70-74). The slag and other evidence from Armagh have not been studied extensively, nor have particularly large amounts of slag been found. However, the distributed nature of the slag finds and comparative evidence from Clonmacnoise, Co. Offaly suggest far more extensive slag deposits, relating to specialised production, may await excavation.

**Clonfad**

While the products of Clonmacnoise’s smiths and smelters are unknown, c. 40km to the east at another ecclesiastical complex there is clear evidence for the highly specialised production of brazed iron bells. Clonfad, Co. Westmeath (IID:058; Stevens 2009; Stevens 2010) was a daughter church of the monastery at Clonard 25km to its east, so probably quite different in nature, status and size to Clonmacnoise. The ironworkers at Clonfad were– based on the parts of the sites currently excavated – almost exclusively smiths, with smelting evidence from the site almost non-existent (Young 2009d). It is likely that bells were not the only objects forged on the site but nonetheless the production of such technically sophisticated objects imply the presence of a highly skilled, full-time specialist smith or smiths with a retinue of apprentices and labourers. The bells made on site were almost certainly produced for use on other church sites and the concentration of Type 1 bells (the type being produced in Clonfad) in the midlands of Ireland suggest Clonfad may have been a major producer in the sixth and seventh centuries AD (Stevens 2010).
**St. Gobnet’s House**

St Gobnet’s House in Ballyvourney, Co. Cork (IID:186) was most likely a site on a different, smaller scale to the ecclesiastical sites discussed above, though it is not clear precisely how much slag was recovered during its excavation (O’Kelly 1952). It was seen by Scott (1990, 100) as a ‘major forge’, similar to those mentioned in the law tracts; he does not appear to have seen it as an ecclesiastical site, despite its associations with St Gobnet and St Abbán and its close proximity to a historic church and graveyard (Harris 1938; O’Kelly 1952; Ua hÉaluighthe 1952). While the scale of smithing on the site is not clear, there was extensive evidence for the smithing (and possibly smelting) of iron associated with a large stone-built circular building and earlier rectangular structures.

There is a strong argument to be made for seeing these structures as smithies associated with an early ecclesiastical site, though the dating of the ironworking is very problematic. The existence of such a substantial structure suggests smithing over a significant period. The strong association of the site with iron production may also be hinted at in the name of its associated saint: Gobnet or Gobnait (Harris 1938, 272 gives nine variations on the spelling of the name). While the connection does not appear to have been made in the literature as of yet, the similarity between this saint’s name and the ancient Irish deity and mythological figure Gobnu/Gobann Saor (see above; Gillies 1981; Scott 1990) seems unlikely to be coincidental considering the ironworking on the site. This may indicate a pre-Christian element to ironworking on the site or in the area.

**Other Sites**

Two sites with very little available information: Brigown, Co. Cork (IID:033; Carroll 2005; 2006) and Kilgobbin, Co. Dublin (IID:120; Bolger 2008) have historical evidence similar to that from St. Gobnet’s House, suggesting ironworking on or near them may have been significant. The townland Brigown translates in Irish to *Bri-gobhunn* or the ‘hill of the smiths’. The hill was reputedly named after a group of smiths, blessed by St Findchu, asked him to name the district after their craft (Moore 1889; Carroll 2005). It is tempting to see in this story and the archaeological evidence for ironworking a hint of a location synonymous with ironworkers. Similarly, the site of Kilgobbin is connected in local tradition with the mythological smith/builder *Gobán Saor*, though the historical evidence for this is thin (Bolger 2008, 87). The co-incidence of evidence for ironworking material on the site might suggest there is more to the local associations than fancy.
Non-Specialist Smithing Sites?

Smithing on a large scale, as discussed above, was actually very rare in the early medieval period. The majority of smithing sites indicate smaller-scale and sometimes very ephemeral smithing. Slag assemblages are good indicators of scales of working and reported weights are often very limited (Table 8.1). In many cases slag quantities are not reported (Table 8.2) but the implication is often that small quantities were found.

Identifying Scale

Unfortunately, it is generally difficult to identify what type of smithing is represented by small slag assemblages. For example, it is difficult to draw a line between the amount of slag that might be generated by recurrent ad-hoc smithing in a particular place and a shorter period of specialist smithing; the chronological resolution and phasing of sites is rarely good enough to understand the duration of smithing activity. Another, un-resolvable, issue lies in the partial excavation of sites and slag collection strategies: it is not always clear if a slag assemblage represents the totality of iron production on a site. Slag may lie outside excavated areas or have been removed from sites to be dumped. For example, there are clear examples of slag being dumped in rivers at Clonmacnoise, Co. Offaly (IID:059; Boland 1996) and Clonfad, Co. Westmeath (IID:058; Stevens 2009).

However, sites with very small slag assemblages, less than c. 10kg, almost certainly represent one-off episodes of smithing. These might relate to ad-hoc repair or manufacture by amateur or semi-skilled individuals; Carlin et al’s (2008b, 110-112) ‘farmer smiths’. However, they could also result from the work of a specialist smith, either permanently itinerant or temporarily working away from his forge.

The Democratisation of Smithing?

Historical sources make little mention of the working of iron by non-specialists (cf. Scott 1990) but the widespread evidence from archaeological excavation for small-scale, episodic and ad-hoc smithing requires explanation. It is possible that all such evidence represents specialist, high-status smiths working, temporarily, away from their workshops or on a more permanent, itinerant, basis. However, it is more likely that the range of small-scale practice represents a similar range of practitioners.

The widespread occurrence of smithing on a variety of site types, particularly settlements, represents a distinct break with the situation in the Irish Iron Age where smithing had a very
restricted distribution (see Chapter 7). The change might be explained by a lifting of taboos,
possibly related to the process of conversion to Christianity and/or an increase in the
availability of iron. The result was a landscape where smithing was routinely practiced in the
midst of daily life on enclosed settlements, crannogs, ecclesiastical sites and burial sites.

In this context it is very likely that knowledge of smithing techniques, the simplest of which can
be learned through observation, became more common. At the same time, the most complex
smithing, learned only through physical practice, would have been the preserve of the full-time
specialists clearly visible in the archaeological record (discussed above). It is likely that a range
of people with a variety of skill-levels worked iron, from handy farmers to apprentices and
journey-men smiths. The fact that a high degree of skill in the craft was recognised in law by
the eighth century (Kelly 1988, 62) suggests that some less-skilled smiths were practicing and
did not command the same degree of respect.

It should however be recognised that smithing was not as common on early medieval sites as
is often suggested (e.g. Proudfoot 1961; Edwards 2005, 283). It is true that a large number of
sites (145) in this study were dated to the early medieval period – or at least that part of the
period included in this study – and a large proportion of these sites had either definite (50) or
possible (15) evidence for smithing. However, this represents a relatively small number
compared with the 241 significant settlement sites in Ireland identified by the Early Medieval
Archaeology Project (O'Sullivan et al. 2010b, xvi), or the more than 2,000 known early
medieval sites (O'Sullivan and Harney 2008b, 12).

**Smiths as builders**

One possible reason for skilled ironworkers to have travelled and to have set up short-term,
temporary workshops may have been their involvement in the construction of buildings. There
is some support for the idea of the smith as builder in the form of Gobban Saor or ‘Gobban the
Wright’ who appears in Irish and Scottish folk tradition but also in early Irish Saint’s Lives
including that of the 5th/6th century Saint, Abbán (Mac Mathúna 1979, 54; Gillies 1981, 73-74),
who was the patron of St Gobnet of Ballyvourney (Harris 1938). Gobban was a smith but also
an acclaimed builder or wright, combining the two highest grades of craftsmen in early
medieval Ireland (Kelly 1988, 61-63).

Slag has been found in the construction or early phases of a number of sites including Knockea,
Co. Limerick (IID:133; O'Kelly 1967), Dressogagh, Co. Armagh (IID:086; Collins 1966), Deer Park
Williams 1985a), Dromthacker, Co. Kerry (IID:088; Cleary 2008) and Urney Park, Co. Tyrone (IID:200; Scott 1971c; 1971b), and slag from later phases could equally be associated with construction. The slag was found under enclosing banks at both Urney Park (Scott 1971b) and Dressogagh (Collins 1966), and slag from the first phase of working at Aghadegnan was associated with the construction phase of a roundhouse (Carroll 1992b).

There are also a number of examples of iron slag from early phases of church sites including Caherlehilan (IID:036; Sheehan 1998; 2000a) and Church Island, Co. Kerry (IID:053; O’Kelly 1958) and High Island, Co. Galway (IID:114; Marshall and Rourke 2000; Young 2006b). Small-scale ironworking may have been required for many phases of building on a site and the manufacture of nails for construction or the repair of tools during the construction of individual buildings may account for the small amounts of slag found on many sites.

**Settlement Enclosures**

A small but still significant amount of slag (86kg) was recovered from the settlement site of Killickaweeny, Co. Kildare (IID:122; Photos-Jones 2004; Walsh 2006). The ironworking on the site is interpreted here as primarily, if not exclusively, from smithing (*contra* Photos-Jones 2004). It was associated with two ironworking areas, one close to a number of structures (Walsh 2008). The site had no evidence for non-ferrous metalworking, though there was significant evidence for textile manufacture on the site (Walsh 2008, 49-51).

The slag assemblage is significantly smaller than those from the large specialist ecclesiastic and secular sites discussed above, despite a large area around the site being stripped (Walsh 2006). However, the presence of probable ironworking structures suggests recurrent smithing on the site. This was probably on a small-scale and over a relatively short period and for local use. The excavator saw the site as lasting only a generation or two with no re-building of structures (Walsh 2008) but it seems likely that the smithing on the site took place over a much shorter span than this.

Two other settlement enclosures: Carnmeen, Co. Down (IID:040; Masser and Dalland 2010) and Mackney, Co. Galway (IID:149; Delaney 2009a) had slag assemblages on a similar, but smaller scale to that from Killickaweeny (51kg and 43kg respectively). The slag from Carnmeen, in combination with the assemblage from the adjacent Henning’s Land (IID:113) site, where slag from Carnmeen may have been dumped, included 56 SHCs, suggesting a significant number of smithing episodes, with a smithing pan from the site indicating repeated smithing in one spot (Cruickshanks and McLaren 2009). If the SHCs are taken to represent one smithing
episode each and a maximum of one day’s work, the smithing at Carnmeen could represent activity over a few months at the most. This suggests it was not a primary activity at the site but was carried out for a relatively short time during one phase of the site’s life.

Similar, but smaller, numbers of SHCs were found at Lagore, Co. Westmeath (IID:135) and Garryduff 1 (IID:103), sites where ironworking probably wasn’t the main focus of activity and may have been carried out by non-specialists or specialists who worked in multiple materials (see discussion above). A comparable amount of slag was found at Mackney, Co. Galway (IID:149) where the ironworking area was associated with postholes, probably indicating a small workshop within the enclosure. The identification of both smelting and smithing at Mackney suggests the production of iron and iron artefacts on a fairly small scale, probably for use by the site’s inhabitants.

Far smaller amounts of slag were recovered from another enclosure at Cahircalla More, Co. Clare (IID:038). The site had good evidence for a forge building on what was probably a settlement site but this evidence was accompanied by very small quantities of slag (16.6kg; Taylor 2006a), far less than would have been generated by a smithy operating over any prolonged period of time. The amount of slag means interpretation as a settlement occupied by specialist craftsmen (suggested by Comber 2008, 124) cannot be sustained unless a larger body of slag is assumed to have been dumped outside the limits of excavation.

One other site, Baronstown 1, Co. Meath (IID:030) demonstrates that significant quantities of slag can remain unexcavated despite large-scale excavations. A tiny amount of slag was found (only 3.36kg) along with a substantial smithing pan weighing 16.9kg. A pan of this size would only have been created in conjunction with a significant amount of slag, indicating further residues, and possibly a smithing area, remains to be found in the vicinity of the site.

These sites are also difficult to interpret but given the small amounts of slag identified and even given the possibility that more awaits excavation it is unlikely they were producing iron for trade. At Cahircalla More the smithing may have been very small-scale, representing a handful, or even only one smithing episode.

**Once-Off/Small-Scale Smithing**

Many sites with small amounts of slag have little or no evidence for a specific ironworking area or structure. Some such as Dromthacker, Co. Kerry (IID:088; Cleary 2008), Coonagh West, Co. Limerick (IID:067; Hull 2007; Taylor 2007; Taylor and Ruttle 2008) and Navan, Co. Meath
had pits or other potential ironworking features but others such as Roestown 2, Co. Meath (IID:178; O’Hara 2007; O’Hara 2009b; 2009a), Aghadegnan (IID:002; Carroll 1991; 1992b; 1992a; 1993b; 1993a) and Cush (IID:073; Ó’Riordáin 1940) in Co. Limerick, Killanully, Co. Cork (IID:121; Mount 1992; 1995) and Dun Emer, Co. Dublin (IID:090; Giacometti 2007b) were not associated with ironworking features and appear to be the ephemeral remains of very limited ironworking, possibly once-off smithing. A large number of other settlement sites have no reported slag quantities (Table 8.2) but it seems safe to assume they did not produce significant slag assemblages.

**Church Sites**

At Reask, Co, Kerry (IID:176; Fanning 1981) smithing (and possibly smelting) appears to have been carried out within stone-built cells in the main enclosure, with slag found distributed throughout the site. The amount of slag found is not clear, making interpretation of the scale of working difficult. However, iron smithing was certainly being practiced on site within permanent structures that could be interpreted as smithies, though this may not have been their primary use. It seems unlikely that the ironworking at Reask represents specialised, full-time smithing for trade. Instead smithing was probably geared to the needs of the site’s inhabitants.

A similar level of activity may be represented by the evidence from Kilpatrick, Co. Westmeath (IID:126; Swan 1976; 1995), though again the amount of slag recovered is not clear. The site appears to have had a specific ironworking area, probably a smithy, where iron objects were being produced. It is not clear for how long this operated or to what extent it represents specialised production but the existence of very large SHCs, as big as 25cm in diameter (Swan 1995), may suggest bloom-refining or primary smithing, probably accompanied by secondary production. Ironworking areas – possible smithies – were also excavated at Tullylish, Co. Down (IID:197; Ivens 1987, 61) and Dunmisk, Co. Tyrone (IID:094; Ivens 1989), though without any indication of slag quantities to suggest the scales of production.

**Once-Off/Small-Scale Smithing**

A number of church sites had evidence for very small-scale sporadic or once-off ironworking. At Church Island, Co. Kerry (IID:053) excavations produced enough slag to suggest ‘several smeltings’ were undertaken (O’Kelly 1958, 116). It is far more likely that the slag remains related to a small number of smithing episodes. The slag came from the earliest phase of the site and could relate to the construction of the early wooden roundhouse. The 24kg of slag from Toureen Peekaun in Co. Tipperary (IID:192) may relate to similar levels of activity though
it is not clear if further slag remains to be found outside the areas excavated (Ó'Carragáin 2008; 2009; Young 2010). Analysis suggested secondary smithing of blooms brought from off-site (Young 2010), probably for use exclusively on-site.

Other ecclesiastical sites produced very ephemeral evidence for ironworking, possibly representing as little as one single episode of smithing or smelting. At Nendrum, Co. Down (IID:163) a few lumps of slag were reported from within and outside the monastic enclosure (Lawlor 1925; Bourke 2007, 407, 419; McErlean 2007, 374-378; McErlean and Crothers 2007a, 68; 2007c, 110). Though it seems likely that in this case the location of ironworking has not yet been excavated and these represent scattered debris from more extensive deposits. At Doras, Co. Tyrone (IID:083; McDowell 1987) c. 8kg of slag was found in trenches scattered over a large area and again it is probable that the ironworking area(s) on the site have yet to be identified, with the slag found representing scattered residues. Unknown, but apparently small, quantities of slag were found at Caherlehillan, Co. Kerry (IID:036; Sheehan 1994; 1996; 1997; 1998; 2000b; 2000a; 2004), from the early phases of the site, while at High Island, Co. Galway (IID:114) a tiny amount of slag was found associated with a smithing hearth which preceded a stone cell built over it (Marshall and Rourke 2000; Scally 2000b; 2000a; 2001; 2004; Young 2006b). These might represent single events related to construction or one-off smithing needs.

Burial Sites

Ironworking in the early medieval period was frequently located close to the dead. Most obviously, this occurred on many of the ecclesiastical sites discussed above, sites which often served as cemeteries as well as settlements and ritual sites. Burial practices in the early medieval period prior to the 8th/9th centuries were diverse, with monastic sites reserved for the burial of high-ranking individuals and the majority of the population generally buried in familial cemeteries (O'Brien 2009a). The morphologies of non-church burial sites were highly variable, including burials within annular and penannular enclosures, in prehistoric mounds and cairns, marked by standing stones and in enclosed and unenclosed ‘secular’ burial grounds (cf. O'Brien 1992; 2003; O'Sullivan and Harney 2008b, 157-189; O'Brien 2009a; McGarry 2010).

The majority of burial sites with evidence for smithing fall into the recently created category of ‘settlement/cemeteries’. There is still considerable debate over the definition, chronology, origins and function of such sites (cf. Clarke and Carlin 2008, 78-79; Baker 2010; Kinsella 2010, 122-126; Ô'Carragáin 2010; O'Sullivan et al. 2010a, 54; Williams 2010b; 2010a) but generally they consist of large enclosures with evidence for multiple inhumation burials as well as agricultural, craft and possibly settlement activities.
Williams (2010b; 2010a) has argued that the association of iron slag with ditches, pits, furnaces, hearths and burials on settlement/cemeteries indicates an ideological connection between the smith and death in the early medieval period, possibly preserving pagan Iron Age beliefs, with the smith playing a pivotal role in conveying the dead to the afterlife. In William’s view these sites were not related to settlement and the evidence for ironworking, grain processing and butchering are actually related to funerary rites.

Smithing (and smelting) was carried out close to burial sites and there is a possibility that it may have been symbolically connected to ironworking, perhaps related to earlier pagan beliefs. However, the evidence for a funerary role for the smith in the early medieval period is very tenuous and ignores very good evidence for widespread conversion to Christianity as early as the fifth century AD (cf. McGarry 2010). It also ignores the extensive evidence for smithing on settlements, ecclesiastical sites and other non-funerary contexts throughout the early medieval period. It is far more likely that ‘secular’ cemeteries were considered appropriate areas for agricultural and craft activities, and probably also settlement, in the early medieval period, much as ecclesiastical cemeteries were.

Settlement/Cemeteries

Johnstown 1 in Co. Meath (IID:117; Clarke and Carlin 2008; Clarke 2010) is one of the best published examples of a settlement/cemetery. It also had by far the largest excavated slag assemblage from a site in this study (2017kg; Table 8.1). Unfortunately, the very long duration of activity on the site over more than a millennium and the scarcity of identifiable ironworking features make interpretation of the ironworking on the site very difficult (see discussions in Chapters 5 and 6). However, the large quantities of slag from individual dumps on the site (Clarke and Carlin 2008) – possibly related to distinct periods of ironworking – measured in hundreds of kilogrammes suggest discrete ironworking episodes on a significant scale. This is likely to have included smelting and certainly included smithing activity.

Some of the ironworking areas, particularly Area 1 (discussed in Chapter 6), may represent the remains of smithies; suggesting the site was used, possibly for significant periods, as the workplace of a smith. The dating of the various ironworking areas on the site is problematic due to long calibrated spans and the use of oak charcoal for dating, making the exact number of distinct ironworking phases very difficult to identify (Fig. 8.2). At least some of the ironworking relates to later, medieval, activity outside the scope of his study. The site may have played host to specialist smiths but the evidence is simply too ambiguous for a definitive interpretation.
Three settlement/cemetery sites at Twomileborris (IID:199; Ó Droma 2008), Castlefarm 1 (IID:048; O’Connell 2009) and Ratoath, Co. Meath (IID:173; Wallace 2010) also had significant, though far smaller, slag assemblages (Table 8.1). No clear ironworking area was found at Castlefarm 1 but analysis of the slag showed it resulted from secondary smithing, probably on a fairly small scale (Wallace 2009b). At Ratoath a similar quantity of slag (73kg) was found and, similarly, the slag was found in ditches with no clear ironworking area identified. The slag was all related to smithing and Wallace (2010, 307) suggested, based on unusual burial practices on the site, that the site may have had links with the Anglo-Saxon world.

Information on the ironworking areas at Twomileborris, Co. Meath (IID:199) is partial but it is clear that ironworking was taking place at different times in different parts of the site (Ó Droma 2008; Mícheál Ó’Droma 2011 Pers. Comm.). Each individual phase of ironworking on the site was on a fairly small scale, probably representing local use. The earliest phase of ironworking, contemporary with Enclosure B may pre-date the early medieval burial evidence on the site. Another settlement/cemetery at Bushfield 1, Co. Laois (IID:034; Wiggins and Kane 2007; N.R.A. 2010e) may have had ironworking on a similar scale to Twomileborris, Castlefarm and Ratoath. A group of Iron Age furnaces were located outside the enclosure on the site but a significant amount of the 80kg of slag recovered came from pits and post-holes excavated within the enclosure (Wiggins and Kane 2007). This may be residual Iron Age slag but there is a good chance some of it was contemporary with the early medieval enclosure.

Other settlement/cemetery sites produced far smaller amounts of slag. At Raystown, Co. Meath (IID:175; Seaver 2009a; 2010) a very small amount of slag was found scattered around the site and was thought to relate to repair/recycling of artefacts. None of the slag was associated, spatially or otherwise, with the burials. However, a significant percentage of the site remains unexcavated leaving the possibility that more slag and an ironworking area may await identification. An extremely small quantity of slag (0.452kg) was identified from the possible settlement/cemetery at Loughboy, Co. Kilkenny (IID:147; Cotter 1999b; McCutcheon 1999) but without specialist analysis even the identification of ferrous slag cannot be definitively confirmed.

It is not clear exactly how much slag was recovered from excavations at Ninch, Co. Meath (McConway 2001a; 2010) but it appears to have been quite small. The slag was found in secondary contexts spread around the site and no ironworking area was identified. An unknown, but probably small – four examples are listed in the finds register (Wilkins and
quantity of slag is reported from Carrowkeel, Co. Galway (IID:047; Wilkins and Lalonde 2008). The slag was found deposited in the enclosure ditch of the site and no ironworking area was identified during the excavation. Finally, a small amount of slag was found during excavations at a possible settlement/cemetery at Marlinstown, Co. Westmeath (IID:151; Keeley 1991a; 1991b; 1992) but very little information about the quantity or context of the slag is available. The evidence from these sites appears to represent sporadic, once-off small-scale smithing episodes.

**Other Burial Sites**

Iron slag dating to the early medieval period has also been identified at a small number of other sites related to burial. One site, at Dooey, Co. Donegal (IID:082; Ó Riordáin and Rynne 1961), could potentially be seen as a settlement/cemetery, though it has also been seen as an emporium (Ó Riordáin and Rynne 1961; O'Sullivan and Breen 2007, 119; Greene 2009; O'Sullivan et al. 2010a, 29). However, the burials on the site belong to a late phase and it may be that the ironworking predated them.

Unknown quantities of iron slag were recovered from the fill of a late Iron Age ringbarrow at Haynestown, Co. Louth (IID:112; O'Sullivan 1994b). The slag came from upper, re-cut, layers of the ditch fill and was associated with early medieval pottery (Muiris O'Sullivan 2010 pers. comm.). Other evidence from the site for early medieval cereal processing suggests it may be similar in some ways to the settlement/cemeteries already discussed. Another prehistoric burial mound, at Gragan West, Co. Clare (IID:106) also produced unspecified quantities of slag (Cotter 1990). The slag was not from a secure context but is probably early medieval based on associations with other artefacts.

Slag from Curraheen 1, Co. Cork (IID:072; Danaher and Cagney 2004) was found in association with cremated human and animal bone in a number of undated pits. The pits were found within the early medieval enclosure on the site and are interpreted here as being contemporary. The site also had evidence for prehistoric burials and it is likely that that cremated bone associated with the slag represents re-working of old deposits, but it is possible that both the slag and the bone could be contemporary and date earlier than the early medieval enclosure. Reworking of an even earlier burial monument was uncovered at Creevykeel, Co. Sligo (IID:069) where at least 30kg of slag was associated with a prehistoric court tomb. The site was excavated very early and there is insufficient evidence to securely interpret the ironworking remains, though associations with early medieval artefacts do
suggest an early medieval date (Hencken 1939). It is not clear if the association with a prehistoric burial monument in this case was significant.

**Crannogs**

Irish crannogs, artificial islands constructed in lake shallows, are frequently dated to the early medieval period in Ireland (OSullivan 1998; O'Sullivan 2000; Fredengren 2002). Only a small number of them have produced evidence for smithing datable to the early medieval period. Of these, a small number with no evidence for settlement have been seen as the island workshops of blacksmiths (Van de Noort and O'Sullivan 2006, 74; O'Sullivan 2009, 85). O’Sullivan (2009, 84-86) links the use of such crannogs, occupying liminal spaces on the edge of society, with the mythical aspect of early medieval smiths, arguing that some smiths may have operated on the fringes of society allowing them to protect the ‘arcane secrets of their trade’. In this view, the smiths using these artificial islands were operating without the protection of a patron, being both feared and misunderstood by the community.

Arguably, there was little need for early medieval smiths to retreat to an island to protect their secrets. Smithing was taking place in many different places, sometimes in the open air, and there does not seem to have been any preoccupation with hiding it or separating it from everyday life on most sites, though forge buildings may have served this purpose in some cases. However, the idea of smiths un-attached to patrons and perhaps travelling outside their own tuath, away from the protection of their own kin is a useful one. There is every reason to believe some smiths may have travelled to where there was demand for their work, seeking their fortune and even their freedom. The seventh/eight century Law Tract *Uraiccecht Bec* suggests un-free individuals could gain their freedom through the skilled practice of blacksmithing or other respected crafts (MacNeill 1921-1924, 273; Buckley 2005, 748).

One crannog, Bofeenaun, Co. Mayo (IID:031; Keane 1995), produced a significant amount of slag (74kg) associated with a hearth and possible anvil stones (discussed in Chapter 6). The amount of slag recovered is not particularly large (cf. Table 8.1), though it is possible that much of the slag produced on the site was disposed of in the lake in which the crannog was situated. It seems clear that the island was indeed used for a time as a smithy but it is less clear if this was the purpose for which it was constructed. The lack of evidence for settlement suggests smithing was carried out for a short period of time. It seems someone worked iron on the island for a period at the beginning of the ninth century but for what reason and for how long remains unclear.
Bofeenaun has no clear parallels from other crannogs, though slag has been recovered from some including Moynagh Lough, Co. Meath (IID:158; Bradley 1983; 1984; 1986a; 1986b; 1991b; 1991a; 1993; 1995; 1997; 1999), Sroove, Co. Sligo (IID:184; Fredengren 2002), Derryhowlaght East, Co. Fermanagh (IID:079; Williams 1994), Lough Faughan, Co. Down (IID:146; Collins 1955) and Lagore, Co. Westmeath (IID:135; Hencken 1950). Sroove is perhaps the most similar site, with smithing on a stony crannog, but only a small (unspecified) amount of slag was reported from Sroove (Fredengren 2002, 237), suggesting the ironworking was much smaller-scale than the smithing at Bofeenaun.

The 3.8kg of iron slag from Moynagh Lough (Bradley 1991b, 23) may represent as little as one episode of smithing in the entire history of the site, possibly related to the much more extensive non-ferrous work on the site. Only a fragment of slag was reported from Derryhowlaght East (Williams 1994) and it is not clear how much slag came from Lough Faughan (Collins 1955), though it is likely to have been small. The weight of iron slag from Lagore was not given in the excavation report (Hencken 1950) but, based on the numbers of slag pieces reported, it is likely to have numbered in the tens of kilogrammes at most. It also came from a very different context to the slag from Bofeenaun (see above).

Isolated Sites

A small number of unclassified, isolated ironworking sites bear some similarities to Bofeenaun. Trumra 4, Co. Laois (ID:194) had the largest slag collection of these sites (116kg), though a large proportion of the assemblage consisted of natural concretions (Young 2008f; O'Neill and Kane 2009). The site appears to have been isolated and dedicated to smithing, with a large proportion of primary smithing, suggesting it may relate to nearby (unexcavated) smelting. A smaller assemblage (54kg) from Kilmacthomas Area 16, Co. Waterford (IID:124) was also devoted to smithing and may have included a smithy building, though there was no contemporary evidence for settlement (Tierney and Elliott 2008). On the same road scheme at Kilmacthomas Area 25 (IID:125; Tierney 2008) a much smaller slag assemblage was also recovered from an isolated site, though the evidence from Area 25 was more enigmatic and it is not clear what activities are represented on the site. A very small amount of slag was also reported from another isolated site at Aghamore, Co. Westmeath (IID:003; Byrnes 2007). These sites were isolated and uni-functional, and seem to represent the existence of isolated smithing sites unrelated to settlement activity. It is impossible to say if they represent the remains of the work of specialist smiths or others engaging with the craft.
Specialist Smelters?

The evidence for smelting from early medieval sites in this study was surprisingly limited when compared with the Iron Age. Only 12 sites had definite evidence for smelting, with another 15 having possible evidence (Table 8.3); furnaces were identified on only six early medieval sites. Smelting was identified on a similar range of site types to smithing (cf. Tables 8.1 and 8.2). However, no large-scale smelting sites, comparable to the large-scale smithing sites discussed above, were identified.

It is not clear if smelting was carried out by smiths in the early medieval period, by specialist smelters or by non-specialist individuals or groups such as farmers. The historical evidence is mixed and does not give a clear indication of who was involved in smelting (Scott 1990, 188). The absence of large-scale smelting does not, however, necessarily negate the possibility of specialist smelters. Smelting could have been carried out on a small-scale by small groups of smelters moving from site to site, though this would be very difficult to identify in the archaeological record and would probably result in a large number of smelting sites (not seen in this study). The small number of smelting sites from the early medieval period raises the possibility that iron stock may have been imported from outside the country.

Settlement Sites

Evidence for smelting from early medieval settlements was ephemeral, with furnaces identified at only two sites, Coonagh West, Co. Limerick (IID:067; Taylor 2007; Keys 2010) and Mackney, Co. Galway (IID:149; Kearns 2007; Dolan 2008a; Delaney 2009a). The first produced 17kg of slag from both smithing and smelting, with a similar but slightly larger (43kg) assemblage from the second. Other sites, including Garryduff 1 (IID:103; O’Kelly 1963) and Oldcourt (IID:167; Murphy 1961) in Co. Cork, Ballyhenry, Co. Antrim (IID:024; Lynn 1983) and Dun Emer (IID:090; Photos-Jones and Wilson 2006a; Giacometti 2007b), Co. Dublin were identified as smelting locations through the identification of mineral ores, and, in the case of Ballyhenry, an unconsolidated bloom. All of the smithing from these sites is indicative of small-scale, non-specialist work probably being carried out by the person smithing the iron on the sites.

Church Sites

A small number of church sites had clear evidence for smelting. At Clonmacnoise, Co. Offaly (IID:059-063) at least 35kg of a slag assemblage weighing 271kg from a linear trench associated with a pipe was from smelting, with 50kg clearly associated with smithing (Young 2005h). Ore
was probably gathered from the surrounding bogs for smelting, with blooms then worked on site (Young 2005h; King 2009, 342). There are strong indications that much larger quantities of slag await excavation at Clonmacnoise (see discussion above) and it is possible that it played host to smelting on a large-scale.

At Ballykilmore 6, Co. Westmeath (IID:025) the early medieval phase of ironworking produced c. 20kg of slag related to smelting (Channing and Quinney 2006; Young 2006d; Channing 2007; Young 2009a). The site is not fully published but appears to have been a previously unrecognised monastic enclosure with a later, medieval church and a large number of burials. The site is located less than four kilometres from Clonfad, Co. Westmeath (IID:058), raising the possibility it was a supplier of iron for the Clonfad bells.

Burial

Definite evidence for early medieval smelting was identified on only one settlement/cemetery site, Johnstown 1, Co. Meath (IID:117), though burials were present at Clonmacnoise, Co. Offaly (IID:059-063) and Ballykilmore, Co. Westmeath (IID:025) discussed above (Table 8.1). It has already been noted that the phasing and duration of ironworking from Johnstown 1 is not well understood and very few verifiable ironworking features could be identified with any confidence (see above). The large quantity of slag from the site (2017kg; Table 8.1) means it may have been an important large-scale smelting site, but unfortunately the available analysis and evidence from the site does not allow further interpretation.

Isolated Sites

One potential opportunity for identifying the activities of specialist smelters might be the identification of sites with relatively elaborate designs indicating a greater investment of energy, thought and time when compared with most sites. A small number of smelting sites demonstrate some complexity, though the small amounts of slag recovered from them indicate fairly short use-lives.

The very unusual site at Grange 2, Co. Meath (IID:108; Kelly 2011a) had a unique design in an Irish context (see Chapter 5; Wallace and Anguilano 2010b; Kelly 2011a; Wallace and Anguilano 2011). The site consisted of a large pit with a shaft furnace at one end and possible evidence for a second shaft and/or a designated roasting area. It is a distinct site in an Irish context in terms of its conception and organisation; the effort, design and expertise evident in its construction hints at the work of a specialist, though there is no de facto evidence for this.
The double furnace at Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006) had a similarly unique design, though it parallels in some ways the furnace at Grange 2 (see discussion in Chapter 5). The well thought-out organisation of Knockbrack, with twin furnaces allowing parallel smelts and a stone-lined area possibly used for smithing, as well as a possible primary smithing site c. 20m from the main smelting area suggests a very efficient and possibly relatively long-term set-up. However, the amount of slag from the site (31kg) is not particularly substantial and unless a separate slag dump is assumed cannot represent ironworking over more than a short period of time.

Smelting and smithing was also carried out at two other isolated early medieval sites, Dollas Lower, Co. Limerick (IID:081) and Carrigoran, Co. Clare (IID:044). At Carrigoran a slag assemblage (30kg) was associated with a smelting furnace and smithing hearth situated close to some field boundaries (Reilly 2000a; 2000b; Young 2005a). Dollas Lower consisted of a furnace, some pits and a posthole in a completely isolated context with an unknown quantity of slag (Dowling and Taylor 2007).

The Chronological Development of Iron Production

Previous sections have demonstrated the range of practice in both smithing and smelting visible in the archaeological record, particularly the extent of specialist vs. non-specialist working. What follows, is an attempt to situate this evidence chronologically, in the context of significant changes in early medieval society. Unsurprisingly, different site types and different activities were not spread evenly across the early medieval period, with a significant increase in number after the seventh century AD (Table 8.4). The imbalance appears to be real, though it may be exaggerated due to the existence of souterrain ware on many later sites. Souterrain ware is a natively produced pottery type introduced to Ireland in the seventh century which continued in use as late as the tenth century, primarily in the North and East of the country (Ryan 1973; Armit 2008). Armit (2008) dates its first appearance to between 650-780 AD and it may have continued in use as late as the twelfth century AD. This makes dates from these sites very broad where complimentary dating evidence was not found, and means some of the sites from this study dated using souterrain ware may in fact date outside the study period.

Conversion/Transition (4th- 6th Centuries AD)

The archaeological evidence from the first half of the early medieval period pre-dates many of the historical sources discussed above and at its beginning overlaps with a pre-Christian, pagan milieu in which the smith probably played a significant social and probably religious role (see
Chapter 7). Clear changes can be seen in the organisation of iron production in the period with the dying out of the association between ironworking and hilltop sites, probably by the end of the fifth century and evidence for ironworking on Christian sites certainly from the early sixth century and possibly earlier.

Only a small number of sites in the study straddle the divide between the Iron Age and early medieval period and it seems significant that chief among them are hilltop enclosures including Clogher, Co. Tyrone (IID:055), Rathgall, Co. Wicklow (IID:171) and Freestone Hill, Co. Kilkenny (IID:099), discussed in Chapter 7 (Table 8.4). The exact function of these hilltop sites in the Late Iron Age/Early Medieval Period is not clear. Freestone Hill has been interpreted as a pagan sanctuary while the ‘hillfort’ at Clogher has been interpreted as a settlement constructed by Romano-British immigrants retaining links with Britain to the end of the Iron Age (Ó’Floinn 2000; Warner 2009). The ironworking at Rathgall appears to have been isolated, though the site awaits publication.

It is not certain that these hilltop sites are definitely related to one another or to the earlier, Iron Age, hilltop sites such as Tara, Co. Meath (IID:188) and Knockaulin, Co. Kildare but they do bear some similarities, including the presence of burial mounds, non-ferrous workshops and long occupation histories. Such sites appear to have been appropriate places to carry out both ferrous and non-ferrous metalworking as well as being places of burial, ritual display and possibly religious or political power at the beginning of the early medieval period, but it appears that after the sixth century AD such sites no longer played host to ironworkers.

**The Emergence of Ecclesiastical Ironworking**

A number of ecclesiastical sites had evidence for ironworking as early as the fifth/sixth centuries AD (Table 8.4). This was mainly small-scale, with one exception: Clonfad, Co. Westmeath (IID:058). Ironworking at Clonfad started very early in the site’s history with historical and radiocarbon dates suggesting the foundation of the site in the first half of the sixth century (Stevens 2009, 17; 2010, 89). Another site in Westmeath: Ballykilmore 6 (IID:025), located less than four kilometres from Clonfad with evidence for smelting may have been contemporary with early smithing at Clonfad (Channing 2007; Young 2009a), with Ballykilmore potentially supplying some of the iron being worked at Clonfad. Smaller-scale ironworking was also underway at Kilpatrick, Co. Westmeath (IID:126), 22km northeast of Clonfad, by the sixth or seventh centuries AD (Swan 1995).
Potentially early evidence for smithing on ecclesiastical sites has also been identified on a number of sites in Co. Kerry. Smithing at Reask (IID:176) on the Dingle peninsula is not closely dated but the site may have been founded as early as the fifth century and continued in use as late as the ninth century (Fanning 1981). Ironworking at Caherlehillan (IID:036) on the Iveragh Peninsula, a short sea-journey from Reask is very possibly early with overlying deposits giving a radiocarbon date range from the sixth to the eighth century AD (Sheehan 2009; O'Sullivan et al. 2010b). Given other evidence from the site for very early occupation associated with B-ware it is possible ironworking was underway on the site in the sixth century AD. Finally, at Church Island (IID:053), a short journey to the west of Caherlehillan, evidence for smithing from the primary phase of the site may well be contemporary with Caherlehillan and/or Reask though the slag from the site is not very well dated (O'Kelly 1958; Hayden 2007; 2008). Other ecclesiastical sites with early ironworking include Cathedral Hill in Armagh (IID:010), Killoran, Co. Tipperary (IID:123; Cross-May et al. 2005), Kiltera, Co. Waterford (IID:129; MacAlister 1938) (IID:129) and possibly the old graveyard at Clonmacnoise, Co. Offaly (IID:062; King 1994a; 1995a; Anon 2009).

These new contexts for ironworking suggest a real change in terms of the places and people involved in the production of iron objects. The Church appears to have taken ownership of the craft and developed it on a new scale for its own purposes. This process would have involved a renegotiation of the role and status of the smith in society. Gillies (1981, 74) suggested that instances in some of the early Irish Saint’s Lives whereby saints bestowed the skills of the smith on individuals could be symbolic statements about the take-over by the church of the smith and his power. An animosity between the previously powerful smiths and the clergy might also be hinted at in the angry reaction of a group of smiths to Brendan and his followers in the eighth century ‘Voyage of St Brendan the Abbott’ (discussed above; Scott 1990, 190; O'Sullivan 2009, 85-86). Ecclesiastical sites possibly associated with pre-Christian smiths such as Brigown (IID:033) and St Gobnet’s House (IID:186) in Co. Cork (see discussion earlier in this chapter) may reflect the incorporation of a pre-existing smith-cult in the south of the country within Christian structures. The similarity in form between the Saint’s name Gobnet and the mythological Gobniu seem to hint at such continuity.

**Ironworking on Settlements**

A limited number of settlements with evidence for ironworking date to the early part of the early medieval period, in contrast with the situation in later centuries (Table 8.4; see below). Nonetheless, the appearance of ironworking on such sites signals a significant change from the Iron Age, from which settlements are largely unknown (see Chapter 7). This may reflect a
general broadening of the demand for iron as well as a lifting or loosening of taboos relating to its practice, probably associated with the influence of Christianity and the Church.

Coonagh West, Co. Limerick (IID:067), a circular settlement enclosure, produced evidence for smelting and smithing dated artefactually to the sixth or seventh centuries (Taylor 2007; Keys 2010). Early evidence for smithing and possibly smelting was also identified at Garranes, Co. Cork (IID:102); dated by finds of B-ware to the later fifth or sixth centuries AD (Ó'Riordáin 1942). Evidence for smithing also came from the settlement enclosure at Cahircalla More, Co. Clare (IID:038; Taylor 2006a) and, on a very small scale, from another enclosure at Dowdstown 2, Co. Meath (IID:084; Cagney and O’Hara 2009; Cagney et al. 2009). The slag from Dowdstown was probably contemporary with enclosure 1 on the site, dated to the fifth or sixth centuries, but it could date significantly later. The slag from Cahircalla More is likely to date to the late sixth or early seventh centuries AD based on two radiocarbon dates on animal bone and cereal grain from the site.

Ironworking at Aghadeegnan, Co. Longford (IID:002) took place subsequent to the construction of a palisade enclosure on the site and prior to the construction of a later banked and ditched enclosure (Carroll 1991; 1992b; 1993b). It was dated by two radiocarbon dates to the fifth or sixth centuries. It is difficult to say for certain if the site still functioned as a settlement in this phase, though it seems likely. The slag from Dromthacker, Co. Kerry (IID:088) was also well dated to the sixth or very early seventh centuries AD, though it is not clear if it was associated with the unenclosed early phase of settlement or the later circular enclosure, or both (Cleary 2008).

The enigmatic site of Altanagh, Co. Tyrone (IID:004-005) had two phases. The first was radiocarbon dated to 433-658 cal. AD (1475±60; UB-2565) on unknown material from an ironworking feature (Williams 1986). The second was broadly dated to 261-619 cal. AD (1585±70; UB-2564) on a combined sample from a number of features. Very little evidence for domestic settlement was found on the site, though it has generally been interpreted as a settlement enclosure (Williams 1986, 51, 58, 69; O’Sullivan et al. 2010b, 647-648). A sword found on the site and possibly manufactured there was dated by Scott (1990, 103) to the sixth or seventh centuries AD, though he did not rule out an earlier date.

**Isolated Smelting and Smithing**

A small number of early sites appear to have been dedicated to ironworking, with no evidence of settlement or other activities. Three sites have fairly tight ranges in the earliest part of the
early medieval period: Caw, Co. Derry (IID:050), Dollas Lower, Co. Limerick (IID:081) and Trumra 4, Co. Laois (IID:194). Dating is more confused for some of the other early dedicated ironworking sites. At Grange 2, Co. Meath (IID:108) two dates were returned with a later date on grain from a higher fill dating 427-555 cal. AD (1561±24; UB-12079) probably more reliable (Kelly 2011a, 31-32; Lyons 2011). Two dates were also returned from Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006) with the most reliable date, on short-lived hazel charcoal spanning 565-666 cal. AD (1420±40; Beta-207372).

These dedicated sites are interesting in that a number of them are among the few sites from the early medieval period with clear evidence for smelting (Table 8.4); perhaps indicating a continuation of the Iron Age tradition of isolated smelting sites (see Chapter 7). Sites such as Knockbrack, Co. Kerry (IID:131) and Grange 2, Co. Meath (IID:108), show some changes in technology, possibly indicating intensification of production on individual sites. However, when combined with the decline in smelting sites this does not provide evidence for an increase in the production of blooms. It may be that some iron was being imported, possibly from Britain or the continent; perhaps through emporia such as those at Dalkey, Co. Dublin (IID:074; Liversage 1968; Doyle 1998) and Dooey, Co. Donegal (IID:082; Ó Riordáin and Rynne 1961; Greene 2009).

**Settlement/Cemetery Sites**

A large proportion of the settlement/cemeteries in the study appear to have early evidence for ironworking, this is unsurprising considering their frequent inclusion of early, presumably pagan, burials (cf. O'Sullivan and Harney 2008a, 78-79; 2008b, 174-181; Bhreathnach 2010; Ó’Carragáin 2010; Table 8.4). Johnstown 1, Co. Meath (IID:117; Clarke 2004; Clarke and Carlin 2008; Clarke and Carlin 2008; Clarke 2010) has the earliest dated evidence from these sites but produced dates spanning the entire early medieval period and later. Other settlement/cemetery sites have less substantial and less certain evidence for ironworking early in the early medieval period. The practice of ironworking on these sites is probably part of the same phenomenon of the widening of the practice of ironworking and lifting of taboos seen on settlement sites.

**Secular Specialisation and the Expansion of Smithing (7th-9th Centuries AD)**

The later part of the early medieval period saw changes both in the types of sites associated with ironworking as well as the number of such sites. The period saw a change in trading systems evidenced by changes in pottery types found on sites (Campbell 2007a; Armit 2008; Doyle 2009; Kelly 2010a), the extensive construction of uni- and multi-vallate settlement
enclosures (cf. Stout 1997; Kerr 2007, 86-100; O'Sullivan and Harney 2008b, 59-61; Kinsella 2010, 91-93) and the abandonment of familial or ancestral cemeteries (O'Brien 2009a; Ó'Carragáin 2010). By the eight century the church was an established, powerful and wealthy force in Irish society, inextricably intermeshed with secular life and politics (Edwards 1990, 100-101; Ó'Cróinín 2005b, 584). This was also the period when the old Irish law tracts were first set down and in which, presumably, the society they describe/proscribe (or something like it) existed (Kelly 1988).

Ironworking in this period seems to have been more ubiquitous, more commonplace than previously. At the same time the smelting of iron seems to have become a more rarefied practice, seldom taking place on secular settlements or even in the isolated locations favoured in the earlier centuries of the early medieval period. This apparent decline in smelting at the same time as large-scale specialist smithing sites were becoming more common, strongly suggests either the centralisation of smelting on sites not yet identified or the importation of iron from Britain or the European continent.

A Domestic Craft

Non-ecclesiastical settlements were by far the largest category of sites in the study with evidence for ironworking in the second half of the early medieval period (Table 8.4). Substantial changes occurred in the secular production of iron with the development of large-scale settlement smithing sites. This increase in scale may have been influenced or inspired by the appropriation and intensification of ironworking by the church in the sixth century (see above). Significantly, clear evidence for smelting is almost totally absent from settlement sites in the period, with the exceptions of Garryduff 1, Co. Cork (IID:103; O'Kelly 1963), Dun Emer, Co. Dublin (IID:090; Photos-Jones and Wilson 2006a; Giacometti 2007b) and Mackney Co. Galway (IID:149; Kearns 2007; Dolan 2008a; Delaney 2009a) while evidence for smithing is quite common.

Large, specialised smiths’ residences have been identified at Lisanisk 2, Co. Monaghan (IID:139), Lowpark, Co. Mayo (IID:148) and Lisleagh 1, Co. Cork (IID:141). The ringfort phase at Lisleagh 1 was dated between the early seventh century and the ninth (Monk 1995, 107), though a calibrated date quoted by Cherubini (2005, 40) gave a tighter range for the ironworking between 690-750 AD. Radiocarbon dates from Lowpark and Lisanisk give fairly wide spans from the seventh to the tenth centuries but focus on the eighth and ninth centuries (Gillespie 2008; Coughlan 2010; Gillespie 2010; Fig. 8.3).
The vast majority of settlement sites from the second half of the early medieval period were much smaller in scale, ranging from single episodes of smithing to small workshops and recurrent ad-hoc smithing. Smithing was also evident on some settlement/cemeteries in this period including Raystown, Co. Meath (IID:175; Seaver 2009a; 2010), Carrowkeel 2, Co. Galway (IID:042; Zajac 2004a; 2004b) and two sites (discussed above) which also had earlier dates: Twomileborris, Co. Tipperary (IID:199) and Johnstown 1, Co. Meath (IID:117).

A large number of settlements had date ranges wider than the study period and two of these: Mackney, Co. Galway (IID:149) and Rinnaraw, Co. Donegal (IID:177) had small but significant slag assemblages. Mackney had good evidence for both smelting and smithing, though the dating of the site is very broad, ranging from the eight to the seventeenth centuries AD (Kearns 2007; Dolan 2008a; Delaney 2009a). Two dates from the metalworking area do not agree, leading the excavator to see the ironworking as taking place over a very long period (Delaney 2009a, 38-39). This is unlikely considering the concentrated nature of the remains and the small slag assemblage. The exact date of the ironworking is therefore unclear and there is a significant chance it may date outside the study period, perhaps in the tenth century. Dates from Rinnaraw were also somewhat confused with two late radiocarbon dates on shell attracting some suspicion and others indicating a seventh to tenth century range, with a probable real range in the ninth or tenth centuries (Comber 2006b, 105-106). The late date for the site combined with the Scandinavian character of the house on the site may indicate the ironworking on the site was of a non-native tradition.

**Ecclesiastical Ironworking**

The Church continued to play a role in the production of iron artefacts on a variety of scales through the later part of the early medieval period, with both smelting and smithing probably taking place at Clonmacnoise, Co. Offaly (IID:059-063) and bell production continuing at Clonfad, Co. Westmeath (IID:058). The items being produced on church and secular sites are likely to have been different. Swords may have been inappropriate products for monastic workshops and bells may not have been the top priority of secular smiths, though further research is needed to prove or disprove such assumptions.

Smaller-scale ironworking continued on many ecclesiastical sites, with evidence from several of the early sites discussed above including Caherlehillan (IID:036), Reask, (IID:176) and Church Island (IID:053) in Co. Kerry, Nendrum, Co. Down (IID:163), Randalstown (IID:169) and Kells (IID:119), Co. Meath. Only a small number of ecclesiastical sites had ironworking closely dated to the period (Table 8.4). One example is the small-scale secondary smithing from Toureen
Peekaun, Co. Tipperary (IID:192) which was dated to the late seventh or first half of the eighth century AD, soon after the death of the site’s founder St. Beccán in 689 AD (Ó’Carragáin 2008; 2009; Young 2010). Ironworking from Kilgobbin, Co. Dublin (IID:120) was also dated to the seventh or eighth centuries AD, though slag was also found in later phases (Bolger 2008). Monastic activity on Inishkea North, Co. Mayo (IID:116) dated to a similar period, though the ironworking from the site was stratigraphically isolated and not directly dated (Henry 1945).

None of the later ecclesiastical sites had clear evidence for smelting on site, though the smelting from the Water Treatment works excavation at Clonmacnoise (IID:063) may date to the period (King 2004; Young 2005h; King 2006; 2009). Other sites with possible smelting include Nendrum, Co. Down (IID:163), Clonfad, Co. Westmeath (IID:058) and St Gobnet’s House, Co. Cork (IID:186) though the evidence from these sites is tentative (Lawlor 1925; O’Kelly 1952; McErlean and Crothers 2007b; Young 2009d). Evidence for smithing is much clearer with the manufacture of brazed bells continuing at Clonfad and secondary smithing also being identified at Toureen Peekaun and probably also High island, Co. Galway (IID:114; Marshall and Rourke 2000; Scally 2000b; 2000a; 2001; 2004; Young 2006b), St Gobnet’s House, Co. Cork (IID:186; O’Kelly 1952) and Armacg (IID:009-011; Gaskell-Brown and Harper 1984; Lynn 1988b; Lynn 1988c; Crothers 1999 ; Hurl 2003). Smithing at Reask (IID:017; Fanning 1981) and Church Island (IID:053; O’Kelly 1958) in Co. Kerry may also date to this period (Table 8.4).

Isolated Sites

Fewer isolated sites, focused on ironworking and with no evidence for settlement or other activity were identified from the second half of the early medieval period (Table 8.4). Knockbrack, Co. Kerry (IID:131) was discussed above and dated to the late sixth or seventh centuries AD (Hull and Taylor 2006). It is the latest isolated smelting site in the study. Indeed, there is a stark lack of clear smelting sites from the later centuries of the early medieval period (Table 8.4). What little smelting has been identified was not isolated, taking place on settlements and enclosures, in contrast to the isolated smelting of preceding centuries. At the same time, the lack of analysis on many sites mean smelting cannot be ruled out.

Crannogs

Ironworking on crannogs largely dates to the latter half of the early medieval period, though evidence from them is variable. Some could have been included in the ‘isolated site’ category as they had evidence for phases dedicated to ironworking but others seem more akin to settlements. Bofeenaun, Co. Mayo (IID:031) was probably dedicated for at least some of its life to ironworking and one of the palisade posts from the site was dated denrochronologically to
804±9 (Keane 1995, 180). Smaller-scale ironworking on Sroove Crannog, Co. Sligo (IID:184) was dated through animal bone and charred wood to cal. AD 663-775 (1290±30; Gr-25306) and cal. AD 777-969 (1160±30; Gr-23305) respectively (Fredengren 2002). A piece of slag recovered during underwater survey at Derryhowlaght East, Co. Fermanagh (IID:079; Williams 1994) was associated with a piece of timber radiocarbon dated to 666-870 cal. AD (1262±38; UB-3719).

The small amount of slag from Moynagh Lough came from phase Y on the site, dated to c. 748 – c. 780 AD and was contemporary with a non-ferrous furnace (Bradley 1991b; 1993). An unknown quantity of slag from Lough Faughan Crannog, Co. Down (IID:146) is less well-dated: the site was seen by the excavator as continuously occupied between the seventh and tenth centuries while e-ware and souterrain ware from the site could push the general chronology for the site both earlier and later (Collins 1955). The ironworking is not closely datable. Finally, the ironworking at Lagore, Co. Meath (IID:135) was assigned by Hencken (1950, 232-233) primarily to his Phase II, though slag was found in all phases on the site. The site can be broadly dated between the seventh and tenth centuries AD and it is not possible to date Phase II or the ironworking from the site any more closely (Hencken 1950; Lynn 1985-86; Warner 1985-86; Comber 1997). The ironworking from these crannogs represents smithing in very different contexts and presumably for very different reasons (see discussion above).

**Scandinavian Impact**

The ninth century AD saw the foundation of Scandinavian settlements in a number of locations in Ireland, some of which would grow to become Ireland’s first urban centres (Edwards 1990; Wallace 2005). It is not clear what the effect the arrival of Scandinavian settlers would have had on native iron technology, though it has previously been seen as the first ‘exposure of Irish smiths to the mainstream of European metal technology’ (Scott 1990, 8). This view was based on an understanding of Irish iron technology as archaic and insular, preserving the use of a bowl furnace technology on the edge of Europe. The evidence from this study suggests there is no reason to believe Irish iron technology was situated outside the European mainstream, though the organisation of production may well have been different.

There is some evidence for ironworkers in some of the Viking towns (O’Sullivan and Harney 2008b, 226). Very little has been published on the topic but iron slag has been found in a number of excavations of Viking Dublin at Fishamble Street 2, Winetavern Street, Bride Street and Temple Bar West (Wallace 1985; 1987b; McMahon 2002; Stillman et al. 2003; Wallace 2005; O’Sullivan and Harney 2008b). It seems likely that at least some of this urban ironworking was specialised and it would have required the importation of quantities of either
ore or smelted iron as well as charcoal. This urbanised iron production must have had an impact on the production, trade and availability of iron, at least in the hinterlands of Scandinavian settlements.

**Ironworking and Society in the Early Medieval Period**

The evidence examined in this chapter for iron production in early medieval Ireland has provided a hitherto unprecedented view of the development of the iron industry over a period encompassing the conversion of the country to Christianity and the development of a literate, well-connected and vibrant society and economy on the island. Previous models of the organisation of the iron industry (outlined in the introduction to this chapter) have presented necessarily simplified models, largely led by the historical sources, of craft specialisation in the period and the social identity of ironworkers in early medieval society.

The evidence reviewed here allows a more nuanced, contextualised and chronologically aware view of the iron industry and those involved in it. It shows that the organisation of iron production was dynamic, changing over the centuries with an apparent rise in the demand for, and consumption of, iron artefacts in both the secular and ecclesiastical spheres. There is clear evidence for specialisation in smithing and possibly smelting, though there is also extensive evidence for small-scale ironworking, much of which was probably carried out by non-specialists with varying levels of skill and involvement in iron production.

**Smelting**

The archaeological evidence demonstrates that smelting was practiced early in the early medieval period at isolated sites including Knockbrack (IID:131), Co. Kerry, Grange 2, Co. Meath (IID:108) and Dollas Lower, Co. Limerick (IID:081) with a move towards smelting on settlement sites later in the period (Table 8.4). It is very difficult, based on the limited evidence to understand who exactly was producing iron blooms in the early medieval period. The early isolated sites appear to draw on an Iron Age tradition of smelting, though there is a clear development in the design of the sites. This may indicate a degree of specialisation, even if only seasonal, whereby small groups would have spent a period of time in isolation from society creating iron and forming it into consolidated blooms and possibly finished objects.

The later smelting on settlement sites might suggest a de-mystifying of the process. For example the smelting (and smithing) at Garryduff 1, Co. Cork (IID:103; O'Kelly 1963) took place
in the context of a non-ferrous workshop and was probably used to provide iron for on-site/local use. The people involved in smelting iron on site may well have been metalworking specialists but were probably not primarily focused on ferrous materials. It is possible that the majority of smelting happened on sites which have yet to be identified archaeologically, but considering the vast number of early medieval sites excavated in recent years (cf. O’Sullivan and Harney 2008b) this seems unlikely. An alternative explanation may be that significant amounts of iron was being imported into the country, either in the form of bloom or stock iron, or perhaps as finished implements.

Potential sources include Britain and the continent, though very large-scale production of iron in England when it was a Roman province (Cleere 1981; Cleere and Crossley 1995; Pleiner 2000, 41-45, 50; Schrüfer-Kolb 2004; Hodgkinson 2009) appears to have come to a halt in the post-Romano-British period and there was a similar decline on the continent where the sixth to eight centuries AD have been called a ‘dark age of ironmaking’ (Pleiner 2000, 54). The apparent lack of smelting may change as more sites are subjected to in-depth analytical study but for the moment the decline in smelting sites from the Iron Age to the early medieval period remains unexplained.

**Smithing**

This chapter has demonstrated the wide variety of archaeological evidence for smithing in the early medieval period, with the scale and number of smithing sites increasing as the period progressed. The archaeological picture strongly suggests that the shapers of iron were far more varied than is suggested by the historical sources.

The evidence for part-time or amateur smiths is by no means certain as it is very difficult to differentiate in the archaeological record between small-scale activity undertaken on an ad-hoc basis by non-specialists and similar work undertaken by visiting or itinerant specialists. However, the evidence for small-scale smithing at sites with non-ferrous workshops such as Garryduff 1 (IID:103; O’Kelly 1963) and Lagore (IID:135; Hencken 1950) suggests smiths specialising in other materials may have practiced ironworking for their own needs. Limited knowledge of ironworking may not have been uncommon and this probably explains many of the smaller-scale smithing sites identified from the period. The dissemination of such knowledge, which appears to have been restricted in the Iron Age either through secrecy or taboo may have been facilitated by the appropriation of ironworking by the Church from the sixth century AD on. Specialist smiths (either secular or religious) did not work alone and they would have required a retinue of hammer strikers, bellows-blowers and other labourers who
could have picked up basic skills and practiced them in a limited way throughout the community.

The view of smiths provided by the historical literature has perhaps skewed our understanding of who smiths were and how smithing influenced their identity and social role. For this reason it is important to ask the question: who were the smiths in early medieval Ireland? The archaeological evidence suggests that by the seventh or eighth century AD there was a group of people holding secular positions defined by their skill in the working of iron; the smiths described in the law tracts. These people appear to have been wealthy and lived in their own settlements, presumably with attached land and herds. There is no evidence that their positions were hereditary or that they passed on their skills to their offspring. None of the potential smith-settlements identified were worked over multiple generations and indeed some appear to have seen smithing sometime after their foundation, perhaps indicating the granting of sites by noble patrons to newly appointed smiths. Indeed, the status (and wealth?) afforded highly skilled smiths may have offered a rare opportunity for social mobility and wealth creation in early medieval Ireland.

In contrast, there is good evidence from monastic sites for long-term ironworking, probably not indicating hereditary positions but rather a system of apprenticeship. It is not clear if the smiths working on monastic sites such as Clonfad and Clonmacnoise were themselves monks though the monks on Iona with the skills of the smith (referred to above) suggest at least some were. It may be that secular apprentices and indeed master-smiths were also employed on monastic complexes; if this was the case it could have provided a mechanism for the spread of smithing skills and possibly a route to wealth (and nobility?) for some apprentices. These highly-skilled monastic and secular smiths provide clear evidence for craft specialisation and were probably involved in the production of finished iron objects for trade. They may have been making different products – it seems unlikely smiths working on monastic sites were involved in the production of weaponry – but they were part of an elite cadre of producers that were probably quite few in number.
9. **A New View of Iron Production in Iron Age and Early Medieval Ireland**

This study has taken advantage of a large corpus of new information on early Irish iron production to reassess our understandings of both the basic technology of iron production and the social contexts in which it was created in the Iron Age and early medieval periods. It has taken a dual approach, combining the traditional technical focus of iron studies with more recent interest in the socio-economic role of iron. It is the first synthetic review of the evidence for Irish iron production in more than two decades and has succeeded in re-assessing evidence from a very wide period, transforming previous understandings of iron technology as well as contributing significant new perspectives on the social lives of people in Iron Age and early medieval Ireland.

An initial review identified 418 sites of potential relevance to this study, with a very large corpus of 202 sites included in the final project database (see the Sites Gazeteer, Appendix 5). These were sites with good evidence for ironworking (smithing or smelting), usually in the form of slag assemblages, and good chronological evidence which dated them to the study period, from the Late Bronze Age/Early Iron Age to the beginning of Scandinavian settlement in Ireland in the ninth century AD. Details were recorded in the database relating to site type, chronology, features, activities, ironworking evidence and ironworking processes (information on sites, features and chronology has been reproduced in Figures, Tables, Maps and Gazeteers in Volume 2). This included detailed information on 174 potential ironworking features, including 89 furnaces, 38 smithing hearths and 47 ironworking features which could fit either category. Some 231 radiocarbon and dendrochronological dates relating to the ironworking in the study were also recorded (see the Chronology Gazeteer, Appendix 5).

The collection and presentation of this data is an achievement in itself, providing the basis for a synthesis of the archaeology and technology of iron production in early Ireland and allowing unprecedented analyses of the role of iron and iron producers in contemporary societies. Both the data collected and the assessment, analysis and re-interpretation built upon it also provide
a very significant platform for future research on early iron production in Ireland and elsewhere, as well as the development of early medieval and Iron Age societies in Ireland and Europe.

The Technological Context of Iron Production

The first aim of this study was a comprehensive reassessment of the technology of iron smelting and smithing in early Ireland, with particular reference to the archaeological features and artefacts produced. This aspect of the research has been very successful with a large number of relevant sites, features and objects, combined with specialist analysis from newer excavations, facilitating a new understanding of Irish smithing and smelting technologies from the study period. This represents a considerable contribution to wider European regional studies of iron technology. At the same time, this study has only begun the process of understanding specific aspects of these technologies. Much further experimental, analytical and excavation work is required before even a basic understanding of technical issues such as the identification of ore sources, iron yields, smithing techniques and the types of objects being produced is achieved.

Smelting

The large number of smelting furnaces (89) and sites (38) identified for this study represent a massive increase in the quantity and quality of such evidence when compared with that previously recognised (c.f. Scott 1990). In general, smelting furnaces identified in this study are simple slag-pit type furnaces, probably with cylindrical and possibly domed or funnel-shaped shafts. There is little evidence for tapping but there is some evidence for variations in form including associated working hollows/pits, arches, overhanging walls and stone/clay linings, indicating a variety of practice through time and space. This represents a definite shift from the previously prevalent understandings of iron smelting furnaces, which have traditionally identified negative features containing iron slag as ‘bowl furnaces’ (see discussion in Chapter 2). This study has demonstrated that iron technology in Ireland was not marginal, preserving an archaic smelting technology centred on the bowl furnace, but rather was part of the mainstream of European iron technology throughout the Iron Age and early medieval periods.

The archaeology of smelting sites in this study, when furnaces are excluded, is surprisingly sparse with very limited evidence for other recognisable feature types or structures. There is good evidence for the use of oak charcoal as well as other wood types but there is little clear evidence for the production of charcoal on smelting sites in the study period. Ore is a
surprisingly rare find from smelting sites, probably due to issues of recognition and survival. Circumstantial evidence, based on the location of smelting sites, concentrated in the midlands, suggests bogs may have been a significant ore source, particularly in the Iron Age (see discussion in Chapters 5 and 7). Smelting sites identified for this study are largely open air, with very few having any evidence for being inside or associated with roofed structures.

The assessment of smelting technology presented in the chapters above has been limited to some extent by the rarity of both smelting furnaces and smelting sites dated to the early medieval period. While furnaces were found on a number of early medieval sites, the majority came from sites dated to the Iron Age. This suggests either a reduction in the frequency of iron production (possibly related to the importation of iron) or a change in smelting technology in the early medieval period which makes it less visible. The problem might also be one of recognition and further excavations as well as the assessment of slag assemblages from early medieval sites is required to resolve this issue.

**Smithing**

The archaeological remains of smithing reviewed for this study are far more diverse than those from smelting. Smithing sites have been identified on many different scales and the finds, features and structures associated with them vary significantly. Smithing took place in a variety of locations and on many different types of site, though in contrast to smelting, evidence for smithing was far more common in the early medieval period than the Iron Age.

Smithing was sometimes practiced outdoors or in isolated locations but this study has identified, for the first time, excellent evidence for the construction of specialist forge buildings. In the later part of the early medieval period, starting in the seventh or eighth centuries AD there is good evidence for the use of ‘sunken forges’, probably associated with the work of full-time, specialist, high-status smiths and their retinues. A number of such forges have been identified on specialist smithing sites including Lowpark, Co. Mayo (IID:148; Gillespie 2008; 2010) and Lisanisk 2, Co. Monaghan (IID:139; Coughlan 2010). Evidence was also identified on a number of early medieval sites for smithing in more conventional rectangular and circular buildings.

A significant number of smithing hearths were identified from sites in this study, though they proved very difficult to characterise. It is clear that hearth morphologies were highly variable, probably depending on function, and their size and shape can vary considerably even within a site. Only 38 definite hearths have been identified; the vast majority are pits, with two having
raised superstructures. Most are unlined, but some have sides or bases lined with clay or stone. There is clear evidence that hearths were generally blown using tuyeres positioned at their edges, pointing down into the charcoal bed.

Importantly, evidence from this study suggests that tuyeres from Irish early medieval smithing sites can be separated typologically into two types. The larger of these two types may be diagnostic of smithing, with such tuyeres almost exclusively associated with smithing activities on sites in this study (see discussion in Chapter 6). The smaller tuyere types have a strong association with non-ferrous pyrotechnical industries including non-ferrous metallurgy and glass-working. This observation has important implications for the interpretation of iron production sites excavated in the future.

New evidence was also identified in this study for the association of blacksmithing with stone tools including anvils, hammers as well as concave mortar stones, similar in morphology to bullaun stones. The association with concave stones has not been demonstrated previously and suggests a re-assessment of traditional interpretations of Irish ‘bullaun’ stones is now required (c.f. Corlett 2009; Dolan 2009). The function of concave stones in Irish smithing is not clear and this is an area that requires further research. A small number of rotary grindstones found on sites in this study with early medieval dates may also be indicators of secondary smithing.

Slag is generally a key identifier for smithing sites, particularly SHCs (Smithing Hearth Bottoms) and hammerscale, but also smithing pans, which were identified from a small number of sites. Very few examples of consolidated bloom, billets or bar iron were identified on sites in this study, contributing to a poor understanding of the availability and trade of stock iron. A broad analysis and characterisation of slag from Irish smithing (and smelting) sites was beyond the scope of this study but it is an area which would benefit greatly from further study.

**The Social Context of Iron Production**

Understanding the social context of iron technology: the role iron as a material, iron production and iron producers played in Iron Age and early medieval societies, was the second major goal of this project. This broad aim was approached through three specific research questions posed in Chapter 1:

- How was iron production organised in the Iron Age and early medieval periods and what implications does this have for the wider organisation of society?
• What was the scale of iron production in different times and places and what implications does this have in terms of control of production, identity, status and ritual/practical knowledge?

• Who were the producers of iron in the Iron Age and early medieval periods, what role did they play in society and to what extent were they specialists?

These questions have been addressed through two case studies focused on the Iron Age and early medieval periods. Each case study concentrated on different elements of the research questions, with the overall goal of contributing a better understanding of the place of iron and iron technology within past societies. It was possible to address all of the research questions, though to different extents in different time periods due to differences in the archaeological evidence available.

Iron Age

The Iron Age case-study took a geographical approach, focusing on a specific region in the Irish midlands where a concentration of ironworking sites, particularly smelting sites, has been identified. Very early dates from sites in the region suggest it may have played host to the first native iron production in Ireland. Cumulatively, the evidence analysed for this study suggests iron smelting was certainly underway by the fifth century BC, and possibly as early as the sixth or even seventh century BC. The introduction of iron production, even where the earliest suggested date is taken, is significantly later than that in other regions of Europe (cf. Sørensen and Thomas 1989; Nørbach 1998; Collard et al. 2006, 406-416; Hjärthner-Holdar 2009). Significantly, this suggests a conservatism in Irish society in the Late Bronze Age which resulted in the postponement of native experimentation with iron technology.

The archaeological evidence from the period of eventual adoption in the seventh to fifth centuries BC is, unfortunately, very limited but society was sufficiently dynamic to adopt an entirely new technology and material. The practitioners of this new technology were integrated into Iron Age social structures in Ireland at a time of apparent economic and social change which resulted in the very different life-ways evident in the Irish Iron Age by the fourth century BC. It has been argued here that society in the study region, and possibly elsewhere in Ireland, was pastoral and heterarchical. The tiny archaeological footprint of Iron Age settlement has been explained here through a nomadic lifestyle and a lack of extreme social stratification. In this non-hierarchical system, it is argued that ironworkers made their place in society through their skilled-crafting, the control of iron and their involvement in communal rituals.
Smelting during the Iron Age in the case study region was carried out almost uniformly in isolated, intimate locations, away from other activities and probably on a seasonal basis. These locations were generally used only once, to produce very limited quantities of iron. They are separate from smithing places, implying a significant degree of control over iron blooms, which were transported to very specific places to be worked into desirable objects. One smelting site, Derrinsallagh 4, Co. Laois (IID:077; Lennon 2009c) is both unusual and special. It produced a very significant number of furnaces indicating it was returned to many times in the Iron Age, perhaps over a period as long as two decades, with new furnaces being constructed in small groups on each occasion and producing small quantities of iron. During its use, Derrinsallagh 4 must have been synonymous with iron and ironworkers and may have been important in the formation of smelter’s social identities. It was one of very few places in the Iron Age landscape with physical evidence for repeated human use over long periods.

The isolated location and intimate scale of smelting on all of these sites, including Derrinsallagh 4, contrasts with the communal, even performative, aspects of smithing in the period. Arguably, smelting and smithing were carried out by the same people, perhaps at different times of the year. However, it seems smelting was a dangerous or taboo activity, related to smithing but unsuitable for performance or communal ritual/knowledge. Ironworkers may have incorporated their craft into the agricultural and ritual seasons, gathering ore, making charcoal and smelting, possibly in secret, out in the landscape and smithing at specific times, probably related to both the agricultural and ritual cycle at particular, special places in the landscape.

Evidence from this study suggests hilltop sites such as Ballydavis, Co. Laois (IID:020-022; Keeley 1996a; 1996b; 1999; Fegan 2006; ÓMaoldúin 2006; ÓMaoldúin 2010), Knockaulin, Co. Kildare (Johnston and Wailes 2007) and Tara, Co. Meath (IID:188; Crew and Rehren 2002; Roche 2002), closely associated with ritual and burial were also considered appropriate locations for smithing in the Iron Age. These sites were foci of communal activity including religious rituals and the construction of monumental structures and enclosures. They were also associated with wider ritual landscapes incorporating earthworks from the Bronze Age and Neolithic periods.

Secondary smithing in the case study region, and possibly elsewhere in Ireland during the Iron Age, seems to have focused on significant hilltop locations that also played host to communal rituals and monumental structures/enclosures requiring shared labour. Hilltop sites such as
Ballydavis, Co. Laois, Knockaulin, Co. Kildare and Tara, Co. Meath were probably communal foci and were associated with wider ritual and burial landscapes. Iron blooms smelted in the landscape seem to have been brought specifically to these sites to be transformed by smiths into finished objects, possibly in front of large audiences. The evidence suggests iron was a symbolically and ideologically charged material in the Iron Age and those who worked it and controlled access to it probably drew power and authority from their association with it, reinforced through public performance of their skill in significant locations.

Importantly, the small-scale of iron production in the Iron Age revealed in this study suggests it was not a common material in the Iron Age. Instead it was probably a prestige, high-status and relatively rare metal in much the same way as bronze or gold were, though with different symbolic meanings and roles. This importance is manifested in the archaeological record through the use of iron in the production of high-status objects such as horse bits, swords and cauldrons. Its significance may have been enhanced by its origin in bogs; important luminal places and the focus of votive deposition and sacrifice in the Iron Age. Evidence from this study suggests iron only became a more common, and perhaps mundane, material in the early medieval period in Ireland.

Early Medieval

The focus of the early medieval case-study was a concept rather than a region: specialisation. Specialisation in the context of this study is defined as the production of objects beyond the needs of the individual/group. A broad approach has been taken, looking at the variation in specialist and non-specialist roles across different site types and through time. This approach has identified clear evidence for the existence of specialist smiths working on a large-scale on both monastic sites and secular settlements. However, it has also provided evidence for a wide range of smaller-scale practice, from one-off smithing episodes to more substantial, recurring work for local needs.

This study has demonstrated, for the first time, the significant role of the church in the development of iron production in Ireland. Large-scale specialisation in iron production seems to have been pioneered by the Church in the fifth or sixth century AD, with its involvement in iron production breaking down previous social conventions and taboos and triggering a massive expansion in the numbers and types of contexts in which iron objects were produced. Small-scale smithing is also evident from the beginning of the early medieval period on church sites. Over all, this suggests an active appropriation of iron production by the church and a dramatic change in the role played by smiths and smelters in Irish society.
The beginning of the early medieval period saw smithing on hilltop sites of somewhat different character from those used in the Iron Age, including Clogher, Co. Tyrone (IID:055; Warner 2000; Warner 2009) and Freestone Hill, Co. Kilkenny (IID:099; Raftery 1969; Ó’Floinn 2000) as well as continued smelting in isolated locations. However, these Iron Age patterns of production changed rapidly from the beginning of the early medieval period. The result of this re-organisation of iron production was, by the second half of the early medieval period, a broadening of the number and types of site associated with smithing, both secular and ecclesiastical, as well as the development of secular smithing on a large scale. There was a diversification of the numbers and types of people involved in ironworking, with the various sites identified in this study suggesting a spectrum of ironworkers from high-status specialists to low-skilled ‘farmer smiths’.

The evidence for specialist smelters is less clear, largely due to the low numbers of sites and their small-scale. A limited selection of isolated sites such as Grange 2, Co. Meath (IID:108; Kelly 2011a) and Knockbrack, Co. Kerry (IID:131; Hull and Taylor 2006) with complex designs may relate to specialist activity but their short-lived nature and the small-scale of the associated slag assemblages make their interpretation as the work of specialists difficult. By the second half of the early medieval period smelting was taking place on settlement and ecclesiastical sites, though there is no clear evidence for an increase in the scale of production, despite the increased use of iron in the period. It is possible that either large-scale smelting sites, as yet unexcavated, were producing iron in the early medieval period or that iron was being imported from Britain or the Continent.

**Suggestions for Future Research**

The aims of this study were very broad in chronological and geographical scope and in terms of the questions asked of the evidence. This was a deliberate attempt to provide an overview of a field which has seen an increase in evidence and research in recent years but little dissemination or synthesis. This broad approach has necessarily meant that many areas of potential research could, unfortunately, only be touched upon. However, it is hoped that by identifying some prospective areas for future research this study can both inspire further research into iron production and provide a technological and social framework in which to situate it.
The theoretical approach of this study draws on an understanding of technology as a social phenomenon, both material and symbolic. This perspective has been used to draw out two very different narratives of iron technology in the Iron Age and early medieval case studies but there is scope for much more detailed theoretical exploration of the role of iron technology in future studies. For example, the symbolic and religious role of iron production in the Irish Iron Age has only been touched on in this study. A much more detailed examination of both the production of iron as well as its use in high-status objects and in ritual and funerary contexts throughout Iron Age Ireland might shed further light on the symbolic role of iron. There is also a need to apply the theoretical approaches used here to other metals and other craft technologies in early Ireland, with the ultimate aim of understanding each technology in relation to the other and in relation to other areas of social life including warfare, agriculture and trade.

A very significant deficit in the study of Irish ironworking, pointed to by Scott (1990) some time ago, is the lack of an in-depth consideration of the actual products of smiths and smelters. There is a pressing need for a survey of iron objects from archaeological sites in Ireland with a view to understanding precisely how iron was used in the past in both a practical and symbolic sense. It is not at all clear what exactly was being made, for what purpose or in what form stock iron was transported/traded. Such a survey would represent a significant undertaking, but even a straightforward examination of excavated artefacts would be extremely useful. If this was combined with X-radiography and metallographic examination of iron objects more light could be shed on techniques and levels of skill in different times and places, building on previous work on Iron Age and early medieval artefacts (e.g. Scott 1971a; 1976b; 1977; 1978b; 1989b; 1990; Hall 1991; 1992; 1995; Moreau 2007).

Another area of research with serious potential is the identification of ores used and their sources. While this study has identified significant evidence for smelting on many sites in Ireland, it has not been possible to identify, in most cases, the sources or types of ore used. While iron ores are common across Ireland, in some parts of the country at least they would not have been locally available: some territories must have been reliant on others for supplies of iron at different times. An understanding of these issues would allow an appreciation of some of these political and economic factors and would inform any future understanding of the social role of iron technology. One possible methodology for identifying ore deposits, particularly in the case of bog ore, could be the examination of aerial photography. This has proved successful in identifying bog ore for this study at Derryarkan Bog, Co. Offaly (see Appendix 2).
An obvious accompaniment to the identification of ore sources is an attempt at a better understanding of the technical aspects of Irish iron technology, including fuel requirements, iron yields, the characterisation of smelting and smithing slag and the provenancing of artefacts. These elements of iron technology have already been explored in many other contexts outside Ireland (e.g. Salter 1982; Kresten 1987; Crew 1991; Crew and Salter 1991; Bullas 1995; Serneels and Crew 1997; Buchwald and Wivel 1998; Host-Madsen and Buchwald 1999; Charlton 2007; Crew and Charlton 2007; Veldhuijzen and Rehren 2007; Blakelock et al. 2009). To address these issues, significant long-term research incorporating fieldwork, excavation, laboratory work and systematic experimental work is required. This has not previously been undertaken in Ireland but the wealth of new evidence identified in this study demonstrates the archaeological evidence required is now available.

Any future large-scale research project should also address the environmental impact of iron production at different times and in different places. Smelting and smithing require significant wood resources for fuel that may have had a major effect on local environments. This is an area of research that has been largely unexplored in Ireland (although see Grant 2004). The signature of iron production has been identified previously through the examination of pollen and other residues from bogs and other wetland environments (e.g. Mighall and Chambers 1989; 1993; 1997; Murphy and Wiltshire 2003) and similar approaches may be useful in Ireland. It would also be of interest to explore the possibilities of identifying the use of peat charcoal as a fuel in early Irish iron production.

This study has touched on the historical evidence for iron production explored by other scholars, particularly Scott (e.g. 1988; 1989a; 1990) but Scott (1990, 217) himself noted the great potential for further insight through the study of early Irish literature. Another historical approach which has yet to be applied in a systematic way to the study of iron is the examination of townland and place names. A small number of iron-related townland names have been noted in the literature and during the course of this research including Cnoc an Iarainn or ‘Ironhills’ in Co. Kildare and Brigown or Bri-gobhunn, ‘the hill of the smiths’ in Co. Cork (cf. Carroll 2005), and it is likely that a detailed survey would yield many more examples which may indicate past locations of smithing, smelting and mining. This technique has been used previously in Norway to locate potential sites of bog ore, indicated by placenames associated with red through iron staining e.g. ‘Red Bog’ (Ole Tveiten 2009 pers. comm.).
The large number of commercial excavations carried out in Ireland in recent years have been fundamental to this project and as more of these sites are analysed and published no doubt the picture presented here and in this project’s appendices will evolve and change. Future research would benefit greatly from a coherent system, preferably online, which would allow access to currently inaccessible ‘grey literature’ to any researcher. At the same time, even with such access, many of the research issues raised here cannot be answered solely through commercial excavation. Instead systematic, multi-disciplinary lab and field-based academic research is required in order to really understand the social and technological context of early Irish iron production.

Epilogue

The topic of this thesis: iron production and iron technology was chosen based on a personal enthusiasm for the material and very limited (secondary school) experience working with it. As part of this research I have been privileged to both learn about and experience some of the work which would have been so important to early practitioners of iron smelting and smithing. I have collected ore from a bog, made charcoal from scratch, smelted iron in a slag-pit furnace and even forged iron in a modern smithy. These experiences, in combination with the intellectual immersion in ironworking afforded by this research has given me a profound respect for the physical effort, brute force and pain involved in the lives of early ironworkers.

This research has been undertaken at a time of great change in Irish archaeology, spanning the height of the Celtic Tiger boom and the lows that have followed it. However, what should not be forgotten, or squandered, is the great legacy that the boom has left us: multiple high-quality excavations, professional reports and excellent analysis as well as high-quality publications and research. It has been a golden age in Irish archaeology, involving a large number of people and its effects will only be fully realised in coming decades. However, it is already clear that our understanding of Ireland’s past is in the process of being radically transformed.

This research has I hope, contributed to this transformation, taking a disparate dataset and demonstrating the huge value and potential within it. Exploring the evidence has been an exciting and rewarding journey, one that will hopefully be taken by many researchers in the coming years. While the frenetic excavations of previous years may be over for some time, the road ahead brings an opportunity for reflection, analysis and thought: a chance to appreciate
the riches that have been uncovered and explore their meaning in contemporary society and in the past.


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