A slator or two:

Exploring the 17th-century slate industry at Ferryland

by

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Abstract

While the use of slate as a building material was not unheard of in the New World, the early 17th-century English colony at Ferryland, Newfoundland was unique among contemporaneous North American settlements in its large-scale use of local slate. First governed by a Welshman, the colony's historical documents and previously undertaken archaeological investigations point to the presence of a substantial slate industry, complete with at least one quarry and a number of skilled tradesmen. Slate is ubiquitous at the colony, making it one of the most important materials used in its construction. However, very little is known about the quarry, the process used to manufacture the many thousands of roof slates used to cover the early buildings or the lives of the craftsmen that called Ferryland home. Using archaeological and ethnographic data, this project seeks to determine how 17th-century quarrying and slate working processes in Newfoundland may have deviated from those of the Old World, as well as confirming possible quarry sites proposed by previous research. Moreover, this project seeks to connect the practices of 17th-century slaters to those of the 19th and 20th centuries, when Newfoundland experienced a resurgence in both the slate quarrying industry and a Welsh cultural presence.

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Dedicated to the memory of my grandfather, Dr. Ian French, who loved the people, history and rugged beauty of Newfoundland as much as I do.

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Chapter 1

Introduction and Background

1.1: Chapter Outline

While the use of slate as a building material was not unheard of in the New World, the early 17th-century English colony at Ferryland, Newfoundland was unique among contemporaneous North American settlements in its large-scale use of locally quarried stone for everything from flagstone floors to roof tiles (Eberlein 1915:248; Gaulton 1997:20). Historical documents and archaeological evidence at the site point to the presence of a substantial slate industry at Ferryland, complete with at least one quarry and a number of skilled tradesmen, including quarrymen and slaters (Wynne 1622b). Slate is found in abundance in the archaeological record, but aside from preliminary studies performed in the 1990s, very little is known about the quarry, the process used to manufacture the many thousands of roof slates which covered the early buildings or the lives of the craftsmen that called Ferryland home. This research project has several goals, formalized into research questions which are discussed in the following section of this chapter: 1) to understand the motivation behind using slate tiles over other conventional roofing material; 2) to determine the spatial distribution of tile manufacturing activity at the plantation site; 3) expand upon previous searches for governor Edward Wynne's 17th-century quarry; and 4) to better understand the social aspects of the industry, including the long-term cultural impact on Newfoundland's population and architecture. Chapter 1 serves to introduce the research questions, historical background and previously conducted investigations upon which this project is built.

Chapter 2 provides an in-depth discussion and comparison of slate and shale as materials, from both a geological and industrial perspective. It also includes a discussion of the use of slate roof tiles in the medieval and early modern periods in England and Wales, including references to the material in various literary and archival sources. An in-depth exposition of extraction methods follows, outlining both traditional and modern methods of above-ground quarrying and underground slate mining and the ways in which mechanization altered the process. The transformational process of turning raw stone into a useable tile is also discussed, based on the traditional techniques of Welsh quarrymen. Finally, the chapter concludes with a brief discussion of slate roof construction and traditional patterns of tile installation.

Chapter 3 presents the bulk of this project's fieldwork and post-excavation analysis, beginning with a discussion of the theoretical frameworks which influenced the proposed methodology. It also presents the results of a research trip to North Wales, which encompassed visits to various quarries, experimental archaeology and consultation with veteran quarrymen. A full overview of archaeological investigations at both the colony site and along the coast of the Southern Shore highway follows. The chapter concludes with the presentation of post-excavation analytical results.

Chapter 4 explores the 19th-century resurgence of Welsh quarryman culture in Newfoundland with the opening of quarries in Trinity Bay and the Bay of Islands. It provides a historical overview of these little-known quarries, as well as discussing the social, political and economic factors which encouraged the emigration of Welsh quarrymen to Newfoundland. Preliminary archaeological investigations of a 19th-century quarrying operation near the town of Hickman's Harbour, Random Island is also presented at the end of this chapter.

Chapter 5 explores the history of slate handicraft production in Wales, as well as discussing various slate objects that have been excavated at Ferryland from 17th- and 18th-century contexts. This chapter endeavours to give further context to these otherwise mundane objects, arguing that they are evidence of a greater cultural practice surrounding the use of slate in both day-to-day and artistic contexts.

Chapter 6 serves to summarize the research discussed in Chapters 1 through 5, discussing the full scope of the 17th-century slate industry at Ferryland, from quarrying and tile manufacturing to the production of various miscellaneous slate objects. This chapter also discusses the continuation of Welsh slating culture in Newfoundland, from the early 17th-century colonial ventures along the eastern shore of the Avalon Peninsula to the 19th-century slate quarries of Trinity Bay.

1.2: A Welsh Focus on Slating and Quarrying

Although there is evidence that some of the earliest colonists originated from Devon, multiple sources have claimed that the first arrivals in Ferryland were in part or entirely comprised of native Welshmen. For example, D.W. Prowse, in his in-depth exposition of Newfoundland's early history, writes that "Wynne was a Welch man and his emigrants as we learn from his contemporaries were also from Wales" (1895:132). However, in this and other sources (Cell 1969) there are no references given to a primary source which verifies the nationality of the first 11 men to inhabit Ferryland. The inclusion of Welsh names such as "Owen Evans" amongst the earliest inhabitants of the plantation does, however, lend credence to this claim (Wynne 1622b). Prowse's claim that the colony's first governor, Captain Edward Wynne, was a Welshman is undoubtedly true. Clues as to his origins come from Wynne himself, as he references both Mount Snowdon and the Welsh harbour of Milford in his unpublished treatise *The Brittish India or A Compendious Discourse tending to Advancement* (Gaulton and Miller 2009:112). Previous work (Gaulton 1997; Gaulton and Miller 2009) has suggested that Edward was tied to the highly esteemed Wynne family of Gwydir, which came to possess vast amounts of land and political power in the 15th and 16th centuries. In spite of a rather detailed history of the family, Edward is nowhere to be found in available archival or genealogical records. There is a possibility, however, that Edward was born into or perhaps even married into one of the many other Wynne/Wynn/Winne families of Wales. A pedigree of the Wynnes of Peniarth, in nearby Merioneth, mentions an Edward Wynn of the parish Llanbrynmair marrying Ellin, the eldest daughter of Maurice ap Robert Wynne of Glyn, Esq. (Wynne 1872:6-7). Ellin's mother, Agnes, was born in 1557, and her eldest brother, William, was the county sheriff in 1618 and 1637 (Wynne 1872:6-7). These dates work well if we assume the Edward mentioned in this genealogy is indeed Captain Wynne, although his military title is suspiciously absent. Llanbrynmair and Peniarth are both within 50 miles (~80 km) of the slate-bearing hills of Blaenau Ffestiniog and Snowdon, and the latter of the two is roughly 100 miles (~160 km) by land from the harbour of Milford. As was common with gentry at the time, there were connections through marriage to both the Gwydir Wynnes and the Vaughan family of Cors-y-Gedol (Wynne 1872:7). Connections to the Vaughans of Golden Grove, who play an important role in the history of Newfoundland (see section 1.4.1), are at present unknown, but certainly not outside the realm of possibility given the strong ties between the Vaughans of Golden Grove and the Wynnes of Gwydir (Gaulton and Miller 2009:113). The genealogy discussed above is interesting but by no means conclusive and highlights the need for further research.

Whether through birth or marriage it is clear that Edward Wynne came from a Welsh family of wealth and status. The rank of Captain was "almost always reserved for gentlemen" and the fluency with which he writes in English, despite Welsh most certainly being his native language, suggests he was educated at an English university like Oxford (Gaulton and Miller 2009:113). While the details of his military service are unknown, his knowledge and experience in such matters becomes evident when one considers the design and construction of the Ferryland colony and its defenses (Gaulton and Miller 2009:113). The familiarity with which he writes of both Snowdon and Milford suggests he may have spent time along the Pembrokeshire coast which separates the two, where slate has been quarried from coastal cliffs since at least the 16th century (see section 2.3.2).

As stated previously, historical documents suggest that some of the early residents of Ferryland also came from Devon, another slate-rich area of Britain, and the quarrying and processing techniques used in both areas are, admittedly, archaeologically indistinguishable (Gaulton 1997:101). In spite of this, the research which follows will concentrate heavily on Welsh quarrying due, in large part, to the presence of Edward Wynne. Whether he was affiliated with the Wynnes of Gwydir or Peniarth matters little, as both families occupied land with good quality slate and a longstanding history of quarrying activity (Gwyn 1999:45). Whether the quarrymen and slaters which Wynne requested hailed from Devon or North Wales also, to some degree, does not matter: the techniques would have been the same, and Wynne's control over the workers as Governor would have had a massive influence — a decidedly Welsh influence — over how the entire quarrying operation was carried out. Given the connections between the Wynnes, Vaughans and Calverts, there is also a good chance that quarrymen and slaters were simply sent from one of the quarries in operation on the Gwydir estate. The following chapters explore the ways in which the quarrying and processing of Welsh slate has transcended the auspices of tradition, developing over the centuries to become an integral part of modern North Wales culture. The beginnings of this transition can be seen in 17th-century Ferryland, where a Welsh governor, solely in charge of the design and construction of Calvert's colony, built and roofed his structures with slate.

1.3: Research Questions

This research project seeks to fill the existing gaps in documentary and archaeological knowledge by addressing the following questions:

1. *Why was slate favoured as a roofing material at Ferryland over other common materials?*

Given that wooden shingles and thatched roofs were more commonly used in colonial construction in North America, and that they were much easier to manufacture (Eberlein 1915:248), why did the early inhabitants of Ferryland undertake the mammoth task of extracting and processing stone? This question aims to explore the cultural, historical, geological and economic reasons for the site's prolific use of slate as a building material, taking into account the cultural background of the original colonists and the environmental conditions of Newfoundland.

2. *Was there a centralised area on the site for working slate, or was the material processed as-needed in close proximity to buildings which were under construction?*

Traditionally, in slate-rich areas such as Wales, quarried stone was worked into the intended final product — be it building stones or roof tiles — as close to the quarry site as possible, minimizing the effort required to move the large, heavy blocks of stone (Isherwood 2014:39). Small, open-fronted buildings known as *waliau* (or *gwaliau*) and, later, large industrial cutting mills were often placed within the confines of the quarry property, and quarried blocks were either transported on sledges or by rail to be processed

(Gwyn 2015:104, 215). Current archaeological evidence, however, suggests that the slate was, in some capacity, being worked in proximity to buildings under construction at Ferryland. Determining whether the slate tiles and stones were fully manufactured (i.e. reduced down from blocks or slabs) in proximity to structures, or simply altered to fit before installation, will help determine to what degree the Ferryland industry deviated from traditional Old World practices.

3. *Are there material signs of 17th-century activity at previously proposed quarry sites? Are there alternative locations for Wynne's quarry? If so, do these material traces point to a large or small scale quarry operation?*

This question aims to confirm, through archaeological means, the use of previously proposed quarry sites and to quantify the scale at which slate extraction was taking place (Gaulton 1997:29-30; see section 1.5). This addresses issues brought to bear in previous questions, as it seeks to assess whether there were structures or other significant features relating to slate stone and tile manufacturing within the vicinity of the quarry/quarries. While waterfront features associated with transporting the material by boat (i.e. a wharf) have likely long since been lost to the sea, there may still be some physical traces of the presence of 17th-century workmen if they did indeed quarry from these specific outcroppings. Moreover, the preliminary surveying performed by Gaulton (1997:29-30) was by no means exhaustive; the location of Wynne's quarry may be elsewhere along the shores of the Avalon Peninsula.

4. *Are there possible alternative interpretations of the other slate artifacts found at Ferryland?*

Artifacts such as slate "pot lids", gaming pieces, gravestone fragments and several pieces of etched sundials have been found in various locations across the colony site, pointing to the production of non-architectural slate handicrafts. Given the skill required to chip angular material like slate into a circle, it may be possible to view objects like potlids and gaming tokens as "practice pieces" or showcases of skill in addition to their assumed utilitarian function. This supposition is bolstered by the fact that one of the pot lids excavated at Ferryland bears etched initials, suggesting that the craftsman who made it wished to sign his work. Revisiting these generally unremarkable utilitarian objects may help shed light on the social lives of the slater(s) who lived and worked at the colony.

1.4: Historical Background of Ferryland

1.4.1: Migratory Fishermen and the Calvert Period

The earliest European visitors to Newfoundland's shores during the early modern period were migratory fishermen who came by the hundreds in the 16th century, keen on exploiting waters which were teeming with cod (Matthews 1973:69). It is during this period of migratory fishing that the first reference to "Farilham" (believed to be the origin of the name "Ferryland") appears on a map drawn by Giovanni Verrazano (Tuck

1996:21). Migratory fishers often arrived in spring and fished until fall, living and working along the shores in temporary structures which were then abandoned over the winter when they returned home with their dried catch. Archaeological remains associated with these temporary structures suggest that Spanish, Portugese, Basque, Norman and Breton fishermen were all present on the Avalon Peninsula during this time (Tuck 1996:26). These same deposits also revealed an indigenous presence in Ferryland, and the occurrence of carbonized European grape seeds within a Beothuk hearth suggests interaction between the two groups (Gaulton and Hawkins 2016:52). By the end of the 16th century fishermen from the West Country of England were the dominant European presence along the eastern coast of Newfoundland (Matthews 1973:71-72).

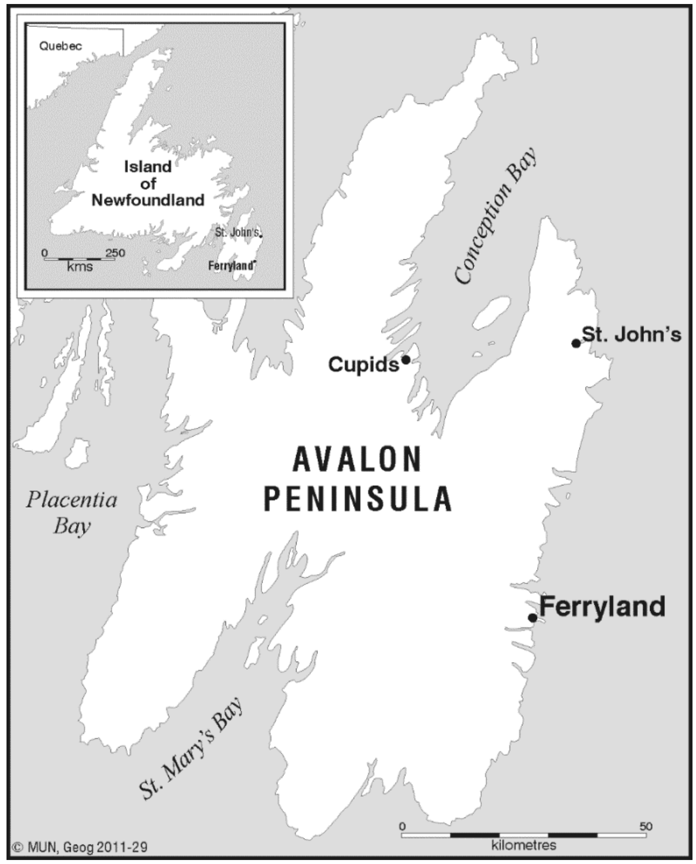

Figure 1: Map of the Avalon Peninsula showing the location of Ferryland.

The early 17th century was a time of increased colonial activity, with settlements at Cupids, Renews and Harbour Grace being established in 1610, 1617 and 1618 respectively (Cell 1981:4, 17, 23; Gaulton 1997:10). Cuper's Cove (now known as Cupids) was the first, established by the Company of Adventurers and Planters of the City of London and Bristol and governed with mixed success by John Guy (Cell 1981:6). The colony of Renews followed, established by a Welsh poet named William Vaughan of Golden Grove (Cell 1969:83). Harbour Grace, known originally as "Bristol's Hope", was settled a year after Renews by merchants from Bristol (Gaulton 1997:116). In 1620 George Calvert, a man of great importance within English political spheres and who had a keen interest in North American colonies, obtained a parcel of land on the Avalon Peninsula from William Vaughan following the failure of the Renews settlement (Gaulton 1997:116; Pope 2004:4). Seeking to make his fortune from the fishery and hoping to create a new home for his family away from the persecution of Catholicism in England, Calvert appointed Captain Edward Wynne, a Welshman, as his governor (Cell 1981:50; Gaulton and Tuck 2003:189). In August of 1621 Wynne and eleven settlers arrived on the shores of Newfoundland and construction of the newly established colony of "Avalon" began in earnest (Gaulton and Tuck 2003:190; Tuck 1996:28). Wynne wrote favourably about the land and its prospects, and in his letter from July 28, 1622, he describes the construction of many structures: a house measuring 44 feet long by 15 feet wide with a large hall and stone chimney, a kitchen and corresponding cellar, a forge, a hen-house, a 16-foot well, palisade fortifications, a wharf, a tenement building and the establishment of a garden (Wynne 1622a). He also mentions that a "salt-work is now almost ready" and that the colonists also "have broken much ground for a brewhouse room and other tenements" (Wynne 1622a).

In 1622 new settlers arrived with Captain Daniel Powell, bringing the total number of permanent residents up to 32 (Wynne 1622b). Documentary sources list a quarryman, one Benjamin Hacker, among the group of colonists; in the very same letter, Wynne declares that “the slate-quarry is in fitting” and then requests “two or three good quarrymen” and “a slator or two” in addition to six stone masons (Wynne 1622b). Any correspondences between Wynne and Calvert after 1622 have been lost to the passage of time, and as a result we know nothing about the quarry, quarrymen or slaters of which Wynne spoke. Wynne’s governorship of Ferryland was apparently short-lived, as he departed from the colony in 1625, leaving the inhabitants to govern themselves (Gaulton 1997:11). Fearing for the security of his investment, Calvert, now bearing the title of Lord Baltimore, visited the colony in 1627 and decided to return the following year with his family and 40 Roman Catholic settlers (Gaulton and Tuck 2003:191). Following skirmishes with the French and a bitter winter in 1628-1629, during which some of the colonists perished, the Calverts departed from Newfoundland for Virginia in 1629 (Tuck 1993:294). Calvert continued to operate the plantation under a number of different governors until his death in 1632, and his son Cecil Calvert maintained proprietorship of Ferryland until 1638 (Gaulton 1997:11; Tuck 1993:294).

1.4.2: Kirke Family Occupation

In 1638 Sir David Kirke was granted a royal charter for the entire island of Newfoundland by Charles I as a reward for his successful campaigns against the French in Quebec (Pope 2004:59). The Kirkes arrived at Ferryland with 100 settlers that same year, expelling the Calverts' governor Captain William Hill and immediately occupying Baltimore's mansion house (Prowse 1895:155-156). Kirke's motives were purely profit-driven, and he began to tax fishing conducted by foreign ships, collect rent on fishing rooms and even charge for tavern licenses (Pope 1986:24-25). It would seem a large sum of his profits were re-invested into the colony, as archaeological evidence points to a great deal of reorganization at Ferryland following the Kirkes' arrival. A number of new structures, including a tavern, were constructed to the east of the mansion house during the 1640s (Ingram 2015:9; Pope 2004:137). There is no archaeological evidence to suggest that Kirke had any slaters or quarrymen in his employ during this phase of construction (Gaulton 2013:283).

David Kirke's proprietorship of the colony came to an end in 1651, when he was recalled to England following the collapse of the monarchy (Cell 1969:121). Subsequent inquests, which scrutinized Kirke's governance and the legitimacy of his claim to the Newfoundland colony, resulted in his imprisonment and the forfeiture of his lands (Pope 2004:59-60). Kirke re-purchased the rights to Ferryland in 1653 but died in prison while awaiting his trial in 1654 (Gaulton and Tuck 2003:209). Following the restoration of the monarchy in 1660, his widow Lady Sara Kirke and several of his sons reoccupied Ferryland (Gaulton 1997:13). Despite the Calverts' legal claim to the Ferryland plantation and their repeated attempts to reclaim it, Sara Kirke continued to control the colony and its trade, and the prosperity which followed earned her the title of "British North America's first woman entrepreneur" (Gaulton and Tuck 2003:209).

1.4.3: Destruction and Abandonment

In September of 1673 four Dutch warships sailed through the defenses at Ferryland, and the attackers "plundered, ruined, fired and destroyed the commodities, cattle, household goods, and other stores" (Pope 1993:110). The colony was rebuilt under the guidance of Lady Kirke and operations continued without upset until 1694, when the French unsuccessfully attempted to capture Ferryland (Ingram 2015:11). Deterred but not defeated, the French returned in 1696, sailing from Placentia with 700 men and several warships (Pope 1993:151). The colonists ultimately surrendered but refused to swear an oath to the French king, and as a result they were taken prisoner in Placentia and the colony was burnt to the ground (Gaulton 1997:14). The settlement was subsequently abandoned. Some of Ferryland's residents returned the following year, but the French attack essentially marks the end of the Kirke occupation as all of David Kirke's sons were deceased by the end of 1697 (Gaulton 2006:30; Ingram 2015:12).

1.5: Previous Excavations at Ferryland

A significant amount of archaeological investigation has already been completed at the Ferryland site, with excavations in the 1960s revealing a plethora of 17th-century finds and structural features like a slate-lined drain (Tuck 1996:24). In 1992 a crew led by Dr. James Tuck began to excavate along the waterfront and uncovered a large storehouse, dated to the 17th century, which had been built of stone and roofed in slate (Gaulton 1997:16; Tuck 1996:24). A significant amount of raw material would have been required for this building alone: nearly 3,700 slate tiles and tile fragments were found in the vicinity of the structure (Gaulton 1997:132). Over the 20 years that have since passed, a number of slate roofed structures have been uncovered; in addition, slate fragments have been found in builder's trenches and in deposits adjacent to these buildings (Carter 1997:32; Gaulton and Tuck 2003:195, 204-205; Gaulton and Tuck 2012:77; Tuck and Gaulton 2013:47). The forge, listed among one of the first structures constructed by Wynne, was roofed in slate, as was the large mansion house to the east (Carter 1997:32; Tuck and Gaulton 2013:47). The latter of these two structures also had a significant deposit of slate chips in its associated builder's trench, situated at the western end of the building (Gaulton and Hawkins 2014:54-55). Excavations in recent years have also uncovered a small stone structure outside the boundaries of the colony's palisade wall; designated as Feature 217, this building dates to the early years of occupation and, along with many of the structures built by Wynne, has a substantial amount of slate tiles associated with it (Gaulton and Hawkins 2017:61). Excavations have made it clear that slate was used during the early 17th century for more than just roofing material, as the site also features a massive slate seawall, many substantial slate-built fireplaces, a slate privy, subsurface drains and flagstone flooring (Gaulton and Tuck 2003:195, 204-205).

Slate roofing is not unique to Ferryland as a colonial site, as roof slates have been found at the Jamestown colony in strata also dated to the early 17th century (Levine 2004:329). While there are naturally-occurring sources of slate along the coast of Virginia and Pennsylvania, quarries in the United States were not in operation until the 18th century and roof slates destined for early settlements were largely imported from Wales

(Sweetser 2004:41). Ferryland is unique among contemporaneous colonial sites in this regard: microfossil analysis has determined that the slate used at the colony came from local deposits, and more recent PXRF data supports that conclusion (Gaulton 1997:27; Lacy et al. 2018:15). Gaulton (1997:28-32) has proposed several possible quarry sites based on the quality of the material, the location of the outcrops, similar microfossil inclusions and the ease with which colonists could transport the heavy stone. Recent investigations undertaken by Robyn Lacy (2017) have also upheld the pattern of slate tile manufacturing waste being found in close proximity to early 17th-century slate roofed structures, with a large deposit having been discovered to the south of Feature 217. The archaeology at Ferryland therefore stands in stark contrast to Old World methods of processing slate, as Welsh slaters traditionally split, trimmed and shaped roof slates in a designated workspace close to the quarry rather than doing so next to buildings under construction (Lindsay 1974). The following research endeavours to explore the ways in which the Ferryland industry deviates from those of the Old World, and the ways in which traditional methods were maintained in new found lands.

Figure 2: Map of excavated features at the Ferryland site (created by Bryn Tapper).

Chapter 2

Slate 101: Geology, History, Extraction and Processing

2.1: Slate, Shale and Roofing in Stone

In order to understand the archaeology of slate and slate tile manufacturing, we have to begin by understanding the material, its extraction and the process of working the stone down into a usable product. Slate is a fine-grained metamorphic rock which is characterized by “well-developed slaty cleavage” — or, in other words, its ability to be cleaved into thin sheets (Cárdenes et al. 2010:191). It is composed primarily of sedimentary layers of mud and sand, laid down during the Cambrian (541-485 MYA), Ordovician (485-443 MYA) and Silurian periods (443-419 MYA), which were then subjected to tectonic pressures, converting the soft layers into hard sedimentary stones like shale (Gwyn 2015:51). The formation of slate requires one further step: metamorphic processes recrystallize the minerals to form flat, flaky parallel structures (Pierpont 1987:10). Good quality slate consists chiefly of layers of white mica, interspersed with quartz and feldspar, while poor quality material — “bastard rock”, as it is sometimes called — often contains inclusions of iron, pyrite, sulphides, mudstone and carbon (Gwyn 2015:51). The secondary mineral composition of slate results in a rainbow of colours which often give clues as to the geographical origin of the stone: slate from the Penrhyn area of Wales tends to be a reddish-purple colour, the Nantlle Valley a grey-green, while slates from Pennsylvania, Georgia and Virginia are characterized by various shades of grey and black (Jenkins 1997:25-26). The colours of Newfoundland slate match those of Welsh sources due to their shared geological history: the sedimentary layers which compose both of these deposits were laid down before the two continents separated and began to drift apart (Gwyn 2015:51; Jenkins 1997:25; Ryan et al. 2010:9). The material has been used throughout history for a variety of purposes, including gravestones, writing tablets and even billiard table tops, due to its durability and the ease with which it can be shaped (Jenkins 1997:28). Slate used for the production of roofing tiles is characterized by exceptional hardness and homogeneity, allowing for large, thin sheets to be cleaved away from blocks of raw stone in a consistent and repeatable manner (Cárdenes et al. 2010:191).

Rather confusingly, the term “slate” can be used for any thin piece of rock used to cover a house, extending to tiles made from limestone, sandstone or shale (Jenkins 1997:36). The tradition of using limestone and sandstone tile is well attested to in the United Kingdom, with surviving examples of such roof treatments being found in Yorkshire and Herefordshire (Jenkins 1997:36). While these stones are quarried like slate, split like slate and hung like slate — and indeed are referred to as “roof slates” — they are not the metamorphic rock from which their name is derived, and the resulting tiles are often thicker, smaller and much “rougher” than those made from legitimate slate (Jenkins 1997:36). Such is the case in Ferryland, where the tiles which roofed the 17th-century structures around the Pool are referred to as “slates” but are in fact largely made from shale, the sedimentary precursor to metamorphic slate. Some examples of true slate do exist, however. While shale is also a fissile, laminate rock composed of mica, quartz and calcite, it was never subjected to the intense heat and pressure inherent in slate deposit formation and as a result does not have the homogeneous crystalline structure of its geological cousin (Vine and Turtelot 1970:253-4). While “slate” was used interchangeably within the mining industry to refer to both types of stone, the distinction between these two materials will become important when considering the archaeological traces of Ferryland's slate tile industry. In our current discussion of material extraction and tile manufacturing, however, the process used for both is nearly identical and therefore the slate quarrying/processing methods used by industries like those in Wales can provide helpful background knowledge to inform later archaeological study.

2.2: Early Use of Slate Roof Tiles

2.2.1: The Use of Slate in the Medieval and Early Modern Period in England

The term slate comes from the late Middle English "slat" or "sclate" and is closely related to the French term for breaking something into pieces: "esclater" (Lindsay 1974:14). While small objects made of slate are found in prehistoric contexts, the Romans were the first to use local slate as a building material in England (Jope and Dunning 1954:209). The southern counties of England, particularly Devon and Cornwall, also made great use of slate in early construction. References to the fireproof nature of slate tile, especially in comparison to commonly used wooden shingles or thatch, were attested to in documentary sources in the late 12th century (Wood 1965:295). Slate's superior fireproofing qualities were referenced again after the Great Fire of London in 1212; when reconstruction efforts commenced after the nearly two-week long fire, it was advised that homes were covered with tile, boards or lead instead of reeds or straw (Lindsay 1974:14). Slate tiles were exported en mass from Dartmouth, Totnes and Plympton as early as 1171, when 800,000 slates were shipped to Winchester and Southampton to cover buildings belonging to King Henry II (Wood 1965:295). Twenty-three thousand "sclattes" are recorded as being purchased in 1296 from Bere Ferrers, Devon to roof miner's cottages in what is now modern day Maristow (Jope and Dunning 1954:210). Documentary references to shipments of "sclats", "sklates" and tiles from Devon, Cornwall and Dorset continue in this fashion through the 14th to 16th centuries (Salzman 1967:233; Wood 1965:295). Quarrying in Cornwall and Devon continued through to modern day, but mining efforts in these areas of England shifted to the extraction of other resources and the English slate industry was ultimately dwarfed by the rise of the Welsh quarries in the 18th and 19th centuries (Lorigan 2007:248).

2.2.2: The Use of Slate in the Medieval and Early Modern Period in Wales

Small household items crafted from slate have been found in early Iron Age contexts in Wales, and the material was commonly used for bakestones throughout the medieval period (Lindsay 1974:14). While it is widely accepted that the Romans were the first to make large-scale use of Welsh deposits for roofing and flooring material, the earliest documentary evidence comes from Ranulf Higden's *Polychronicon*, originally written in the latter half of the 14th century, in which he describes the landscape and resources of North Wales witnessed during his travels:

Valeys bryngeth forth food,
And hills metal right good,
Col groweth under lond,
And grass above at the hond,
There lyme is copious,
And sclattes also for hous.
[translated by John Trevisa (1865:Vol 1)]

It is known that Conwy and Caernarfon Castles were roofed with slate tile in the 14th century, but aside from these two examples stone was not a common roofing material in Wales until the 16th century (Lindsay 1974:20). The main exception to this rule is the town of Conwy, which was described as having "much slate on the houses" in a chronicle for the year 1399 (translated by John Webb [1899]). Pembrokeshire in south-west Wales was also an area of early slate extraction, with multiple documentary sources from the 16th century referencing requests and shipments of slate to roof houses and cathedrals alike (Lindsay 1974:22). The poet John Leland, in his writings about Dulas Island, remarked that "the houses be of tymbre and slated" and went on to state that the local inhabitants "dig oute slate stones to kyver houses" (Leland in Hearne 1744:85). Welsh slate was exported to a small degree to Ireland during the latter half of the 16th century, but it is generally believed that early quarries served only to supply local markets (Lindsay 1974:24; Wood 1965:295). Both the export and popularity of roofing slates intensified in Wales through the 17th and 18th centuries, culminating with the establishment of the Penrhyn and Dinorwic quarries in the 1770s and 1780s (Jones 1981:15; Lindsay 1974:26). The opening of these quarries heralded the beginning of industrial-scale extraction and catalyzed a number of large social and economic changes in the country (for an in-depth discussion, see Jones 1981). These topics will be explored further in subsequent chapters.

2.3: Extraction

2.3.1: Basics of Quarrying

Slate can be found in veins sandwiched between "posts" of igneous rock like sandstone or dolerite, crosscut by lines of pyrite or quartz (Gwyn 2015:51). These veins occur both above and below ground at various angles — sometimes near vertical, sometimes oriented as low as 20° — and this angle determines the method of quarrying (Gwyn 2015:51; Isherwood 2014:25). Steeply oriented outcrops are more suitable for above-ground open face or pit quarries, while low-angled veins, which often dip below the surface, require underground workings more akin to mining than quarrying (Gwyn 2015:60).

Successful extraction in either case requires knowledge of the various "planes" of stone and the geological processes which form them (see Figure 3). The slate's cleavage plane, or grain, should not be confused with sedimentary bedding planes: the latter is formed by the accumulation of silt, while the former is created by the recrystallization of minerals during the metamorphic transformation from mudstone/shale to slate (Pierpont 1987:10). It is the cleavage plane which allows for the stone to be cleaved away from the outcrop and subsequently split into fine sheets, although the bedding planes of limestone and shale can be exploited in much the same way (Isherwood 2014:25; Pierpont 1987:13). The "pillaring line", which is a man-made breaking point, runs at a right angle to the cleavage plane and serves to break the wide bed of a vein or outcrop into more manageable-sized blocks (Gwyn 2015:55; Isherwood 2014:27). "Bevels" are lines of mineral inclusions which run horizontally or diagonally across the cleavage plane, compromising its integrity and quality, and they are often areas of weakness where the slab will break during extraction (Isherwood 2014:27). A “foot joint” also runs horizontally across the cleavage plane and, as the name suggests, delineates the bottom of a block (Gwyn 2015:55). Similarly, the “free top” delineates the top; both of these lines can be naturally occurring (following a bevel) or man-made using the same process used to create pillaring lines (see below; Gwyn 2015:55; Isherwood 2014:27). The cleavage plane therefore determines the thickness of a block at the time it detaches from the quarry face, while the pillaring line, foot joint and free top determines its length and width. Quarrymen were able to recognize or even create the various planes of stone and exploit areas of weakness, like bevels, to maximize the extraction of quality slate (Gwyn 2015:65).

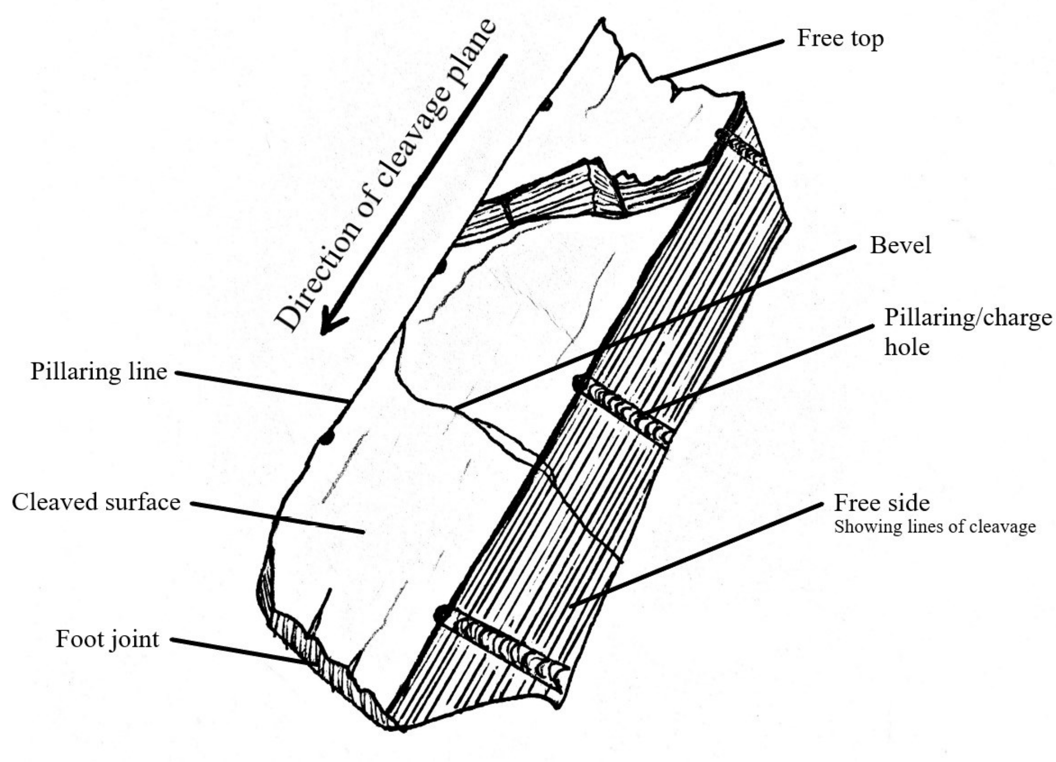

Figure 3: The anatomy of a quarried slate block.

2.3.2: Historic Quarrying Methods

The earliest quarries were known as "single-face" operations which took advantage of steeply angled slate outcrops exposed along coastlines and on hillsides (Gwyn 2015:54). Working these deposits was simple but also rather dangerous: quarrymen, sometimes suspended by a single rope tied in a half-hitch around their thigh, would use pry bars or drive wooden wedges with hammers along the cleavage plane to detach large slabs; these mammoth pieces of rock would then free-fall to the quarry floor below (Gwyn 2015:54, 65-66). The design of these single-face operations meant that smaller outcrops of decent quality could be exploited or at the very least explored without much effort, as was the case in the Cilgerran Gorge in south-west Wales (Gwyn 2015:54). When these workings became too unstable or simply too high to be worked, opening up the quarry floor into a pit, allowing for the exploitation of below-ground material, was the next step (Gwyn 2015:58). A shaft would be sunk in the centre of the quarry floor and then widened out; 18th-century workings in the Nantlle Valley of Wales achieved depths of over 100 metres by sinking successive 20 metre shafts using this method (Gwyn 2015:58). Both the single-face and open-pit strategies left much to be desired however, as they were not only wasteful but incredibly hazardous: the blocks often shattered upon impact, sending debris flying in all directions and oftentimes reducing the useability of the material. In the case of pit working, there was the added complication of raising the material from the pit floor, and this was often done with ropes and baskets or rudimentary counter-balanced cranes and inclines (Gwyn 2015:58, 148, 155).

Where deposits were large enough and space was not an issue, extracting the materials from galleries or benches was often the method of choice, whether single-face or pit quarrying was being used. Not only did it make the workings much more organised and the workforce easier to manage, but it also prevented unnecessary loss (both of material and human lives) in addition to simplifying issues inherent in moving large amounts of quarried stone (Gwyn 2015:54). Slate pried from the galleries had less distance to fall, resulting in less breakage, and the benches also allowed for the stone to be worked from both the top and the sides (Gwyn 2015:54). Long galleries, up to 20m across in small early quarries and much longer in modern Welsh quarries like Dinorwic (see Figure 4), increased the need for "channeling" to create pillaring lines, a method whereby a line of holes was drilled or a channel gouged into the rock at right angles to the cleavage plane using percussive force (Isherwood 2014:25). Small augers or large chisels (known as the *trosol mawr* in Welsh) were used for this task, ensuring that the stone broke precisely where the quarrymen intended (Gwyn 2015:67; Sylwedydd n.d.:13). While little documentary evidence exists of early slate quarrying in Wales, engravings of galleried quarries from Anjou, France dating to the first half of the 18th century give hints as to the methods and tools used. These images show workers hammering wooden wedges into the stone along the gallery tops to open the cleavage plane, while others used pickaxes at the face to pry down blocks and break them into more manageable sizes (Diderot 1768:Vol 6, Plate I; see Figure 5a). Rudimentary counter-balanced cranes, operated using body weight, were used to lift slate in baskets from lower benches to upper levels, while another shows a series of rope-and-pulley systems perched high atop the quarry face (Diderot 1768:Vol 6, Plates I and II; see Figs. 5b and 5c). These simple extraction methods are also attested to in George Owen's *Description of Pembrokeshire*, which was written in the early 17th century: slate was "cloven by iron bars to the thickenes of a foot or halffe a foot, and in breadth iij or iiij foote" (Owen 1892:82). This document also describes the process of using wooden wedges in seaside quarries to harness the rising tide, the moisture from which led to the expansion of the wood and the opening of the cleavage plane of the stone (Owen 1892:82). The wooden wedges depicted at Anjou and described by Owen were later superseded by a method known as "plug and feather", in which expanding metal spikes were driven into the stone using a large hammer, known as the *rhys* in Welsh, to force the stone to split (Gwyn 2015:66). This method could also be used to cross-cut quarried blocks to make them smaller and easier to transport (Gwyn 2015:66).

Figure 4: Galleries of Dinorwic Quarry, Llanberis, North Wales.

The introduction of explosives in the late 18th century required the preparation of charge or shot holes, and with this new task came a new tool: the jumper, or *jympar*, which was a large iron bar over 2m in length with a large "swelling" of metal two thirds down its shaft and a steel-tipped chiseled end (Gwyn 2015:67; Lewis 1987:64). These bars became the primary method of creating pillaring lines by repeatedly driving the *jympar* at right angles to the rock face or cleavage plane (see Figure 3), slowly gouging out a hole; this task was slow and laborious, and it could take a quarryman an entire day to drill a single charge hole (Gwyn 2015:67). Similar charge holes were drilled along the cleavage plane and cracks were opened in the stone on all sides using a "gentle explosive" like black powder (Isherwood 2014:27). Once loosened, the block could be pried from the face using a crowbar and prepared for transport (Isherwood 2014:27). The block was initially "pillared", split lengthwise again along a pillaring line created using one or a combination of the previously noted methods and tools (Gwyn 2015:103). The block was then cross-cut perpendicular to the pillaring line across its face, a risky process which often led to material loss and relied heavily on both brute force and luck (Gwyn 2015:103; Isherwood 2014:39). While most un-mechanized quarries made use of hammers, chisels and wedges to perform this task, early examples of hand-operated toothed saws are also attested to in the south-west of Wales (Richards 1998:25-26).

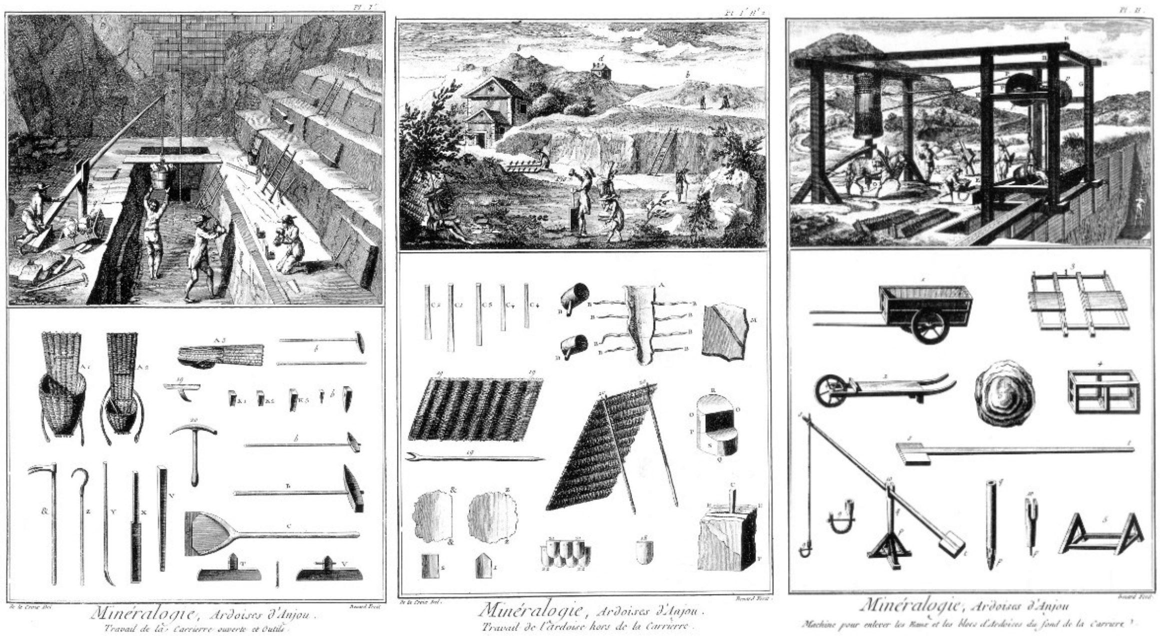

Figure 5a (left): Galleried slate quarry in Anjou, France. Figure 5b (centre): 18th-century methods of slate processing. Figure 5c (right): 18th-century quarry haulage system using horse-powered pulleys. All plates are from Diderot 1768: Vol 6.

While Owen's descriptions and the engravings from Anjou paint an orderly, almost sterile picture of slate extraction, it is highly unlikely that early slate quarries were so tidy and well-organised. It was in fact a highly inefficient industry, with sometimes more than 90 percent of quarried material being discarded as waste; all of this material had to be transported away from the working face and deposited where it would not interfere with extraction (Gwyn 2015:52; Isherwood 2014:28). Early quarries made use of sledges drawn by pack animals to pull blocks along trackways, eventually being replaced by horse-drawn wagons and then wheeled carts on rails (Gwyn 2015:216-217; Lindsay 1974:11-12). Prior to the introduction of mining locomotives, manpower was the primary source of propulsion for these carts. A whole division of quarry workers were dedicated to the task of transporting waste rock away from the face: these were the "bad rockmen", who pushed carts filled to the brim with slate and dumped them on waste piles known as "tips" or "tipping piles" (Gwyn 2015:73). Tips dominate the quarrying landscape in Wales and are often visible from kilometres away, dwarfing the quarries themselves in size. Evidence for the use of small watercraft in early quarry operations also exists, with the discovery of a small vessel, dating to the late 18th century, on the lakebottom of Llyn Padarn, Wales in proximity to quarry workings (Dafydd Jones, pers. comm., 28 May 2018). Similar vessels are depicted in contemporaneous paintings being loaded with slate at quarryside docks for transport, and it would not be a stretch to assume that early coastal workings also made use of watercraft to transport the stone and its byproducts (Gwyn 2015:220-221).

2.3.3: Early Slate Mining

While there are unconfirmed accounts of slate mining[1] in the 16th century at Aberllefenni in Wales, the large-scale exploitation of subterranean deposits did not become commonplace in the United Kingdom until the 19th century (Gwyn 2015:9; Richards 1995:13). A growing need for high quality material, driven by the building boom which followed the Industrial Revolution, drove quarry owners to begin hollowing out the mountains of Gwynedd County (Lindsay 1974:117). The exact method of starting these underground complexes varied however, being largely dependent on the angle of the vein(s) and the properties of the stone layers overlying the slate. The initial stages involved driving a combination of shafts (vertical tunnels), adits (horizontal tunnels) or

[1] It is worth noting that underground workings are still typically referred to as "quarries" in North Wales, but to avoid confusion the terms "mine" and "mining" are used to distinguish these procedures from those used above ground.

inclines (diagonal tunnels) from the surface to the desired maximum depth in order to provide access to the material (Isherwood 2014:25). Additional passages would then run horizontally from these initial openings at regular intervals, typically 12 metres (approx. 40 feet), to form the various vertical levels of the mine (Gwyn 2015:60). The removal of stone was achieved through the generous use of rails and carts, and both waste rock and slabs were winched up inclines and shafts (Isherwood 2014:28). From these horizontal levels the standard method of “pillar and chamber” could be used, whereby large caverns were opened upwards, from the bottom of the level to the top, following the angle of the vein until quarrymen hit “the hard”: a layer of sandstone, granite or dolerite that was often present on either side of a workable vein (Isherwood 2014:25). Quarrymen would begin by carving out a narrow “roofing shaft” that ran through the centre of the intended chamber along its entire vertical length, followed by extending out the base of the chamber to its maximum intended width (Isherwood 2014:25). Prepared in this fashion, the remainder of the stone could then be extracted and removed along the tramway at the base (Isherwood 2014:25). While chambers were usually considered exhausted when they reached the tramway of the next level, some deposits were “worked home” up and through the tramway and chamber above until the quarrymen struck hard, and in doing so chambers could reach over 30 metres (approx. 100ft) in height (Isherwood 2014:27). Pillars of stone, anywhere from 9 to 15 metres wide, were left in between the chambers to prevent the mountain from collapsing inward, although the custom of “pillar robbing” to extract as much stone as possible was commonplace and often had disastrous consequences (Gwyn 2015:60; Isherwood 2014:25; Jones 1981:37). Additional chambers and inclines were often added on to initial workings in order to accommodate facilities for the quarrymen, provide ventilation and allow for the further exploitation of deeper deposits (Gwyn 2015:60). Prior to mechanization the tools and methods for extracting stone were identical to those used above ground, making use of galleried benches, jumpers, wedges, picks and plug-and-feather to slowly open up the cavernous chambers. The same aboveground custom of wrapping chain or rope around the thigh to secure a quarryman as he worked his way up a chamber was also used, and hobnail boots were often necessary to ensure he did not lose his footing on the wet stone (Gwyn 2015:60). While the methods were similar, there were new challenges associated with working underground. The risk of collapse was very real, and rock falls were a common cause of death within slate mines in Wales (Isherwood 2014:93). Early underground workings did not have the luxury of electric lighting; all of the work was done by candlelight and, later, by carbide lamp (Gwyn 2015:65). A sharp-eyed visitor to the now abandoned Cwmorthin Quarry, armed with a suitably bright flashlight, can still see the stubs of tallow candles lining the walls of tunnels and chambers. The lack of light coupled with the dizzying heights of the chambers, which sometimes had bridges or walkways across their tops, also resulted in a number of fatal falls (Isherwood 2014:93). Traditional, non-mechanised quarrying techniques endured into the 19th century in North Wales due, in part, to its remoteness (Lindsay 1974:11). As industrialization spread across Europe, new technologies and methods were adopted to more efficiently extract, process and transport slate.

2.3.4: Mechanization

The painstakingly slow process of drilling charge holes by hand and the laborious nature of pushing stone-laden carts led many quarry owners to introduce new machinery in order to maximize profits, especially during the peak years of the industry during the mid-19th century (Lindsay 1974:129-130). The replacement of the jumper with mechanical drills vastly improved the speed at which extraction could take place; steam-powered rotary models were the first mechanical drills used in North Wales quarries during the 1850s, followed by a number of different iterations of percussive drills between 1870 and 1890 (Gwyn 2015:68-69). Unfortunately, distinguishing between a shot hole created by a jumper and one made by a mechanical drill is difficult as both operated using percussive force and both types of charge hole often have very similar diameters (Gwyn 2015:67-68). The process of cross-cutting and pillaring a quarried slab, which also relied on jumpers, chisels, wedges, hammers and brute force, was another task which stood to be improved by the adoption of mechanical saws. The earliest saws, dating back to the Roman occupation of Wales, were hand-operated devices with wrought iron blades cleverly designed to make use of the sand and dust which accumulated in the cut to aid in sawing; as previously stated, large two-handed models were in use in Pembrokeshire in the early 19th century (Boon 1960:171; Richards 1998:25-26). Blocks sawn in this way exhibit a smooth edge with a visible ridge where the slab has broken off (Gwyn 2015:108). Wire saws, which cut the stone using a steel cord cooled by water, were experimentally introduced in the late 19th century with mixed success (Jones 2005:131-132). The use of both wire saws and diamond-tipped chainsaws continues in active Welsh quarries today, and both methods leave tell-tale striations in the stone

(Gwyn 2015:70, 118). Regardless of whether the slate is quarried above or below ground, using traditional or modern methods, the process of manufacturing roofing tiles is more or less the same.

2.4: Processing

After a quarried block is pillared, cross-cut and transported away from the face, it must be further worked into the intended final product. If the stone is intended to be used as slate-stone, that is, as building blocks and large slabs, the prepared block must be additionally pillared and cross-cut to size (Gwyn 2015:103). Large circular saws driven by water-powered line shafts were in use in North Wales by 1860, and modern versions using diamond-tipped cutting teeth are still commonplace in slate mills today (Gwyn 2015:115, 118; Isherwood 2014:39). Blocks cut by circular saw are identifiable by obvious, curved striations along their edge (see Figure 6), distinguishing them from older hand-sawn examples. However, if the quarried stone was destined to become roofing tile, a number of processing steps, many of them still done by hand, became necessary.

Figure 6: Striations on a circular sawn slate block.

2.4.1: Splitting

This crucial first step involves splitting a prepared block along the cleavage plane into thin sheets of predetermined thickness; the delicate nature of this procedure necessitates it be done by hand in Welsh quarries even today. Photos and written accounts from the 18th and 19th centuries in Gwynedd County depict and describe men sat on low chairs in rudimentary three-sided structures known as *gwaliau,* or “lairs”. These structures were often constructed from slate stone waste with a roof made from large slabs, and their open fronts allowed for both raw blocks and finished product to be loaded on and off an adjacent cart track (Gwyn 2015:103; Isherwood 2014:39). The earliest documentary evidence of these structures is from a 1793 map of Penrhyn quarry, which depicts three-sided buildings labelled as “cabbins” perched atop tipping piles (Gwyn 2015:104). Slaters sat with their feet outstretched and crossed in front of them, resting a block up against a piece of cloth or leather draped over their thigh (see Figure 7). The end of a broad steel chisel was placed along the cleavage plane and repeatedly tapped with a wooden mallet to separate the laminae[2] of the stone (Carwyn Price, pers. comm., 31 May 2018). If it did not readily split the quarryman would need to move the mallet across the edge of the block as he tapped, occasionally flipping it to work it from another side (Carwyn Price, pers. comm., 31 May 2018). Using nothing more than a chisel and mallet, a skilled quarryman could split good quality stone into sheets measuring only 1.5mm thick (Gwyn 2015:106). While 17th-century documentary evidence of this practice is difficult to come by, the use of mallets and wedge-shaped implements to split stone is

[2] Thin sheets which separate along the cleavage plane.

depicted in the 18^{th}-century Diderot engravings from Anjou, France (1768:Vol 6, Plate 2; see Figure 5). Given that slate slabs were used to line 3^{rd}-century Roman cellars in Segontium (now modern day Caernarfon), it would not be a stretch to assume that similar methods of splitting slate had been devised by that point in time (Lindsay 1974:18). Observations of modern-day splitting demonstrations at the Welsh Slate Museum in Llanberis have revealed that, if the slate is of sufficient quality, little to no material is lost in this process and the slate breaks into clean, even sheets with little difficulty.

2.4.2: Trimming

Once split, the rough tile must be trimmed down to size. Tiles produced through the medieval period and into the early modern period were not standardized; these tiles, which were often thicker and "rustic" in appearance, were known as "randoms" and were sold by weight rather than by count (Gwyn 2015:32). Standardized tile sizes appear to have at least been commonplace enough in the 17^{th} century for Randle Holme to note them in the third book of his *Academy of Armory:*

Short Haghattee.
Long Haghattee.
Farwells.
Chitts.
Warnetts.
Shorts.
Shorts save one, or short so won.
Short Backs.
Long Backs.
Bachlers.
Wivetts.

Short Twelves.
Long Twelves.
Jenny why Jettest thou.
Rogue why Winkest thou.
The shortest Slate is about 4 Inches, all the rest exceed an Inch,
one in length from the other; sometimes less or more,
according as the Work-man pleaseth.
[1688: Chapter 5, Item 150b]

This newly-developed ability to standardize sizes may have been made possible by access to better quality material as quarrying methods became more sophisticated, rather than trying to salvage what could be used from outcropped stone. The tradition of humorous size names continued through the 18th and 19th centuries, with large quarries like Dinorwic, Penrhyn and Cwmorthin offering "tally slates" in sizes like "Singles" (10" x 8"), "Doubles" (13" x 7"), "Broad Ladies" (19" x 9"), "Countesses" (20" x 10") and "Empresses" (26" x 16"), to name a few (Gwyn 2015:32). In order to ensure consistency a notched stick with a nail or small metal bar set in its end (known in Welsh as the *pric mesur*) is used to mark the split tiles, with the notches corresponding to the standard sizes offered by the quarry (Carwyn Price, pers. comm., 28 May 2018). The edge of the slate is rested in the notch and the metal on the opposite end is then ran across the face of the tile, marking the area to be trimmed (Carwyn Price, pers. comm., 28 May 2018). Randle Holme also lists a "lathing measure" and a "stone measure" in *Academy of Armory*, suggesting that the use of such measuring implements dates back to at least the 17th century (1688:Book III, Chapter 5). Score marks on tiles from a 4th-century Roman villa in Abermagwr have led some to believe that the use of the *pric mesur* has even earlier origins (Gwyn 2015:35).

Once the tile has been marked to size, the excess stone must be removed. The tool of choice for Welsh slaters was (and still is) the *cyllel fach*, or "small knife": a long, dull blade with a wooden handle (Gwyn 2015:106). Such tools are also attested to in Holme's *Academy of Amory*, where he lists "a slaters hatchet" and "a hewing knife to cut the slates even and square" among the tools used by a 17th-century slater (1688:Book III, Chapter 5). The hatchet of which Holme speaks, also referred to today as a "slater's axe", is similar in form and function to the *cyllel fach* but is shorter and wider, with more modern versions featuring a sharp pick on the non-cutting edge for the purpose of punching nail holes (see below; Gwyn 2015:34). Modern hand-trimming (sometimes also referred to as "dressing" the slate) is done upon a *trafel*, a long iron bar mounted on blocks of wood at a downward angle (Gwyn 2015:106; Isherwood 2014:39; see Figure 7). The higher end is set between the slater's legs and the tile is rested upon the edge of the metal at the point at which it is intended to break. The slater removes excess material using the trimming knife in short, chopping motions, from the proximal to the distal end of the tile, continuing on all sides in this fashion until the slate is cut to its intended size (Carwyn Price, pers. comm., 28 May 2018). The *trafel* and fixtures like it appear to have been in use in Wales and in France in the 18th century, but earlier methods likely involved any sufficiently square stone or block which could produce a neat edge (Gwyn 2015:107). Holme's *Academy of Amory* once again supports this notion, listing among the typical repertoire of slaters tools "a hewing block, any square piece of wood or stone to cut the slates upon" (1688:Book III, Chapter 5). The process has seemingly changed very little since the 17th century: an illustration from the same volume depicts a man sat in front of a square block, tile rested upon it, with a large blade raised above his head in his right hand (Holme

1688:Book III, Chapter 5). Thousands of tiles could be produced in this manner within a day, resulting in a great deal of fine trimming waste that accumulated at the slater's feet (JohnJo Jones, pers. comm., 28 May 2018). As with most stages of tile production, this step was also made more efficient with the creation of mechanical dressing machines, although these were adopted with mixed success (Gwyn 2015:118). Rotary dressing machines, which trimmed the edges of the slates using a rotating blade mounted inside a cylindrical housing, were integrated into line-shaft driven mills across Wales during the latter half of the 19th century (Isherwood 2014:39).

Figure 7: Quarrymen splitting slate and hand-trimming at a *trafel* outside of the *gwaliau* at Penrhyn Quarry (Amgueddfa Cymru/National Museum Wales).

2.4.3: Finishing

In order to prepare the trimmed tile for installation, a few final steps are required. Holes need to be punched in order to allow for the finished product to be mounted to the roof using wooden pegs or iron nails. This was traditionally done using a pick or a specialized tool known as a roofer's hammer, an implement which resembles a traditional nail hammer with a long, curved pick in place of nail-pulling prongs. This step can also be achieved using the pick present on a slater's hatchet/axe (Gwyn 2015:34, 107). The tile is struck with the pick from the flat back (known as the "bed") of the tile, leaving a distinctive diamond-shaped hole and resulting in the loss of material from the front face due to percussive force; this leaves a recessed bevel that allows the head of a nail or peg to sit flush with the face of the tile (Carwyn Price, pers. comm., 28 May 2018). Moving the pick from side to side widens the initial hole until it reaches a sufficient size. Hand presses and, later, hydraulic punches were used to automate this step as the percussive force of the pick had the potential to shatter the tile and human error sometimes resulted in sub-optimal hole placement (Gwyn 2015:107). This step was as necessary in the 17th century as it is today according to Holme, who lists the following in his account of slaters' toolkits: "a pick to make a hole in the slate" and "a pinning iron to widen the hole in the slate to put the pin in" (1688:Book III, Chapter 5). Large slates, or those which were destined to be installed on rooves in exposed areas, sometimes needed two or three nail holes to keep them in place (Gwyn 2015:35). While modern tally slates are installed as-is, early "random" or "ton" tiles (so named because they were sold by the ton) may have required some amount of re-shaping prior to installation due to the lack of standardized sizes (Gwyn 2015:32; JohnJo Jones, pers. comm., 28 May 2018).

2.5: Slate Roof Construction

While an in-depth discussion of the nuances of slate roofing is not necessary as part of this research, it is worth quickly explaining how the stone tiles are installed. Generally speaking, the methods have changed very little over the centuries, with the rule being that the bottom bevel (or "tail") of a tile must overlap the nail holes of the tiles in the course below it (Gwyn 2015:35). While more modern techniques are simplified through the use of uniformly sized slates, different strategies had to be used in early roofing. In instances where tiles of varying sizes were used, as is the case with early "randoms", the larger, thicker tiles were laid down at the bottom of the roof near the eaves and became gradually smaller and thinner as they reached the peak; this is known as a "graduated" pattern and is still commonly used in Wales today (Jenkins 1997:201). It was also common practice to use slates with off-centre nail holes and tapered heads in order to "compress" the roof towards its centre, shifting the weight of the roof inwards, for added stability and longevity (Gwyn 2015:35). Tiles in the centre of the roof would have centrally positioned nail holes, while tiles on the left and right would have off-centre holes oriented towards the centre of the roof. Gaulton (1997:132) noted in his excavations of the waterfront premises in Area C that multiple sizes of tiles were present within a single context, suggesting that the graduated pattern was employed during the early construction phases of the Ferryland colony. Recent archaeological work undertaken by both Gaulton and the author (to be discussed in subsequent chapters) supports this proposition. Examples of tapered, off-centre tiles can also be found in the Ferryland collection, suggesting the strategy of compression was also in use during the 17th century in Newfoundland (see Figure 8).

Figure 8: An in-situ tapered roof tile from Ferryland, with contours highlighted in white. This tile would have been hung on the right side of the roof, with the nail hole oriented towards the centre. Photo by Barry Gaulton.

Tiles were affixed to wooden laths which ran horizontally across the roof joists, and the slates were traditionally bedded in moss to make them more resistant to wind and water (Jenkins 1997:199). In the 19th century "torching" became a common method, whereby the tiles were bedded in a mortar made from lime plaster and cow or horsehair (Gwyn 2015:35). "Open slating", affixing tiles without any sort of backing, was used for barns and other outbuildings to allow for ventilation (Gwyn 2015:35). Early medieval sources refer to wooden pegs, "sclatpynnes", as being the preferred method of securing a tile, although examples of iron nail use date back as far as the Roman period in Wales

(Gwyn 2015:34; Salzman 1967:234-235). Indeed, even Randal Holme refers to "pins, stone nails or lath nails, and laths or latts", suggesting that both wooden pegs and iron nails were used to install tiles in the 17th century (1688:Book III, Chapter 5). While nails were costly and susceptible to corrosion, they were considered to have superior windproofing properties and were better suited for larger, heavier tiles (Gwyn 2015:35). This may be why iron nails were used to secure roofing tiles during the early 17th century in Ferryland, where we find examples of corroded nail shafts still embedded in holes across the site.

Chapter 3

Fieldwork: Theory, Methods and Results

3.1: Theoretical Perspectives and Proposed Methodology

The fieldwork and analytical methods described in this chapter, undertaken both in Newfoundland and in North Wales, were influenced by two major theoretical perspectives: taskscape theory and the ethnohistorical approach in archaeology.

3.1.1: Taskscape Theory

The term "taskscape" was introduced by Ingold (1993) in his discussion of landscapes and temporality. He defines a task as "any practical operation, carried out by a skilled agent in an environment, as part of his or her normal business of life", and suggests that a taskscape is comprised of interrelated activities in the same sense that a landscape is comprised of "an array of related features" (Ingold 1993:158). Ingold goes on to suggest that taskscapes can be explored qualitatively, allowing archaeologists to interpret the myriad of activities associated with day-to-day life (Ingold 1993:158). These "socially constructed space[s]" are a result of "continuous interactivity between landscape and humans", and the archaeology at Ferryland exhibits just that: humans collecting, using and discarding materials taken directly from both the land and sea (Rajala and Mills 2017:10). The activities associated with the colony's slate industry have left enduring traces both in the archaeological record and upon the greater landscape, and Ingold (1993) argues that it is these traces which allow archaeologists to interpret a network of socially interconnected tasks. This theoretical approach has already been successfully applied to research involving roofing materials: Pirjo Hamari used taskscape theory to inform her analysis of ceramic roof tile use in Roman Petra (2017). In her explorations of ceramic tile form, function and distribution, she considers how social, geographical and temporal factors combine to form a *ceramiscene*: "the landscape that is created, manipulated and experienced by the manufacturing, usage and disposal of material of deliberately fired clay" (Hamari 2017:105). This approach can be adapted to explore the spatial, temporal and social aspects of slate working at Ferryland, informed by the understanding that the numerous activities associated with slate as a building material form a distinct taskscape all their own.

3.1.2: Ethnohistorical Approach

Given that traditional Welsh slate working practices are still alive today, incorporating ethnographic sources can complement both past and future archaeological and historical evidence. The ethnohistoric approach in archaeology is one "in which the combined resources of archaeological, ethnological and historical data have been utilized to construct a … more complete cultural description than could have been formed on the basis of a single body of data" (Baerreis 1961:55). Thus documentary evidence and archaeological excavation work hand-in-hand to supplement and enhance each other: archaeology benefits from "sources of analogy and hypotheses", while ethnohistoric accounts of the past can be supported, enhanced or questioned using the information gathered from material traces of human activity (Wilson and Rogers 1993:7). While this approach is typically applied to prehistoric or non-Western cultures, it stands to reason that ethnographic and historic data could be even more effectively applied to archaeology from recent European history (Wilson and Rogers 1993:7). There are a number of avenues through which the 17th-century slate industry at Ferryland could be explored — archaeological evidence, historical documents or the ethnographic accounts of present-day Welsh slaters — but a more well-rounded and complete account can be obtained by combining them together.

3.1.3: Proposed Methodology

In order to address the research questions outlined in Chapter 1, both archaeological fieldwork and post-excavation analysis were proposed. Two significant fieldwork components were deemed necessary during project planning, influenced by the above theoretical perspectives: one archaeological, and the other a combination of experimental and ethnographic. The archaeological component involved investigations at both the colony of Avalon and at proposed quarry sites north of the Pool. Test pits adjacent to early 17th-century slate roofed structures, such as the waterfront storehouse (Area C), forge (Area B) and mansion house (Area F), were planned in the hopes of locating artifacts and deposits of slate waste potentially associated with tile manufacturing. Additional excavation in the vicinity of an early 17th-century stone building discovered in 2016 (Feature 217, Area D) was also deemed necessary, with the primary aim of excavating a nearby slate deposit identified that same year (Gaulton and Hawkins 2017:61-63; Lacy 2017:185-186). The intent was not only to quantify the deposits by size and thickness, but also to assess the shape and size of the slate fragments in order to give an indication of both the scale and stage of work at each individual structure. The identification and excavation of potential quarry sites in the vicinity of the

Pool, both along the Southern Shore Highway and inland, was also deemed necessary to answer questions relating to the location of Wynne's 1622 quarry. Systematic test pitting was proposed in the hopes of locating early 17^{th}-century artifacts and evidence of slate working.

The interpretation of the archaeological data will be complemented not only by historical accounts but also through consultation with professional slaters from North Wales; this segment of fieldwork ties directly into the ethnohistorical approach discussed above. A ten day research trip to the Snowdonia region was arranged in order to allow for the surveying of various slate quarries, some of which were worked in the 17^{th} century (potential sites were sourced from Richards 2007 and Williams and Lewis 1989). Many of these quarries have small-scale workings which were used briefly but intensely, making them a good analog for the type of quarry likely in use at the Ferryland colony. These pedestrian surveys would aid in identifying evidence of quarrying activity in Newfoundland, providing comparative examples of both structural remains and quarried outcroppings. Consultations with professional quarrymen at the National Slate Museum in Llanberis, who perform demonstrations of traditional roof slate manufacturing, also had the potential to aid in interpreting archaeological data. Samples of the cast-off waste fragments collected at each stage of the process would also allow for comparative analysis of the fragments found archaeologically in Newfoundland. Using these comparative samples, it should be possible to infer what stage(s) of slate tile formation are represented in the various archaeological deposits at Ferryland. In addition, this bit of experimental archaeology would provide first-hand knowledge of the manufacturing process. It was also proposed that examples of Ferryland roof tiles and samples of raw slate could be transported to Wales and examined in an effort to assess the quality of the material and the skill of the slaters who worked it (relative, of course, to present-day Welsh standards). Further interviews with slaters and historians at the museum were planned around quarrying methods, traditional work spaces, common tools and other aspects of day-to-day life in the quarries.

In terms of analytical methods, the comparative analysis of slate fragments was proposed using both weight and size data gathered from archaeological samples collected during fieldwork. Weight data could be easily collected using a laboratory scale, and the use of length and width data, which would also provide an approximate surface area, could be used to investigate relationships of size. In order to determine which stage(s) of slate roof tile manufacturing are represented in the archaeological record, the above measurements could be plotted on a histogram; multiple bell curves, in theory, would signal the presence of multiple discrete groups or stages. A one-way ANOVA (analysis of variance) test could then be used to detect a significant difference between the multiple averages and the range of measurements in each group, providing further statistical verification. T-tests could then be used to compare these measurements to those taken from the Welsh experimental samples, ensuring that any differences present are indeed statistically significant.

3.2: Research Trip to North Wales

3.2.1: Llanberis Slate Museum

Myself and a volunteer were graciously given unfettered access to the National Slate Museum by its director, Dr. Dafydd Roberts. The museum is situated within the

Figure 9: A collection of hand tools used by quarrymen. The *pric mesur* can be seen on the far right with a roofer's hammer to its left. A trimming knife and splitting chisel are on the far left.

Padarn Country Park in Llanberis and occupies the 19th-century forges, workshops and mill buildings which processed slate from the nearby Dinorwic quarry. The property also features a row of four quarrymen's cottages, collectively known as Fron Haul, which were constructed during different periods of Welsh quarrying history, spanning from the mid-19th century up until 1969 when Dinorwic ceased operations. Although the technology used within these buildings is more modern than the focus of this thesis, the museum offers information related to extraction and quarrying techniques that have been in use since the Roman occupation of Britain, as well as exploring the social aspects of quarryman culture in Wales. Of particular interest to this project are collections of historical hand tools, including *pric mesur* sticks, hammers, chisels, *jympars* and pry bars (see Figure 9). One workshop features the remains of a small late 18th-century boat, discovered on the lakebottom of Llyn Padarn, which had been used to transport slates before the installation of a railway (see Figure 10); similar vessels may have been used by 17th-century quarrymen in Ferryland to transport material from a seaside quarry to a work area.

Figure 10: The remains of the 18th-century Llyn Padarn boat with some of its cargo in the foreground.

While the proposed plan was to physically bring examples of Ferryland artifacts to Wales for the quarrymen to inspect, the logistical challenges inherent in transporting archaeological materials across international borders led me to photograph roof tiles and other slate objects instead. Immediately, the inferior nature of the Ferryland material, relative to that found in Wales, became apparent. All of the quarrymen present remarked about the crude nature of the tiles and the difficulty with which the stone was likely worked. The consensus amongst the quarrymen was that a considerable amount of skill would have been required to make anything usable from such coarse material. It seems likely that Lord Baltimore did not send apprentices to Ferryland upon Wynne's request, but rather skilled slaters who could work with less-than-ideal stone.

The main reason for the visit to Llanberis was to watch the slate splitting demonstrations, which are held several times a day by veteran quarrymen from the nearby Penrhyn quarry. As stated previously, the process of working slate by hand has changed very little since the 17th century. The demonstration begins with a quarryman sitting on a low stool with a small block of slate, measuring roughly 30cm x 30cm x 10cm, resting upon the outside of the thigh. Using a broad, triangular chisel known as the *cyn manhollt* (a specialized splitting chisel that is custom made by the museum's blacksmith), the quarryman gently taps along the grain of the stone across the edge of the block. Occasionally, to "help" the stone, it is necessary to rotate the block and tap the chisel along another edge. After this initial step the quarryman places the chisel along the cleavage plane and with a few forceful taps a thin sheet of slate is separated from the block. This stage, when performed with good quality stone, produces no discernable waste other than a small cloud of dust. After explaining the various slate sizes and demonstrating the use of the measuring stick, the quarryman sits at the *trafel* with a trimming knife and, using small chopping motions, slowly removes excess material to reduce the slate down to the desired size. This stage produces large amounts of small, thin chips of slate as well as a great deal of dust; it was this slate waste that was collected after four separate demonstrations for comparative analysis. The Llanberis demonstrations differ from traditional slate working in one important way: rather than punching the hole with a roofer's hammer, the quarrymen use a lever-action press which punches a perfectly round hole in the slate. In addition to making tiles, the quarrymen produce slate products of all shapes, including fans, hearts and even Welsh dragons. When asked how difficult it would be to manufacture a round potlid, one of the quarrymen trimmed down a square slate in less than two minutes. While they make it look easy, my own attempts at trimming resulted in the production of some less-than-impressive tiles. Drawing with their fingers in the dust on the slate slab floor, the quarrymen also explained the different planes (explained in Chapter 2), the way stone behaves in the presence of inclusions and how slabs are cut to minimize waste. In addition to a large bag of slate chips, I was graciously gifted several tiles (all differently coloured, to showcase the variation in stone from different regions/veins), two potlids and a small slate heart.

The final segment of the day involved a tour of the nearby Vivian quarry, a small working face that is part of the much larger Dinorwic quarry. The Vaynol Estate, upon which Vivian and Dinorwic sit, has been worked since the late 1780s but experienced its peak during the latter half of the 19th century. Although modern in respect to this thesis project, the site has some relevance given that it is a galleried working face that was quarried by hand (see Figure 11a). Stone was transported using gravity-assisted inclines and in some cases hauled with nothing more than manpower and rope; the rows of *gwaliau*, where quarrymen split and trimmed slates by hand, have been preserved as part of the museum property (See Figure 11b). These three-sided structures, arranged neatly in a row along the railway, were still full of trimming debris and unfinished tiles. Vivian proved to be a good example of a small but intensely-worked galleried face and, along with the quarries visited below, aided in identifying possible 17th-century quarry sites back in Newfoundland.

Figure 11a (left): The galleries of Vivian Quarry. Figure 11b (right): The structural remains of Vivian's row of *gwaliau*, with an adjacent overgrown rail line from the quarry face.

3.2.2: Quarry Tours

One of the first quarries visited on this trip was the Tyllau-Duon or Llaneilian quarry, located on the north shore of Anglesey. The site is made up of a series of seaside cliff-face workings which have been exploited since the 17th century, making it a place of particular interest (Richards 2007:35). After being sporadically worked for centuries, the North Anglesey Slate & Slab Co. began more organized operations at the site in the late 19th century, employing roughly a dozen men (Richards 2007:35) These later operations appear to have obliterated any signs of earlier 17th-century workings. Access to the site during the 19th century was by wooden ladder from above or via a set of stairs carved into the rock face, both of which are presently inaccessible without the use of ropes and harnesses. From the water, however, the galleried working faces become evident, even in their overgrown state, as does an adit (a horizontal tunnel) which was used to access deposits of copper (see Figure 12). Although no longer present, a small quay allowed for the transportation of quarried material by boat, and the lack of tipping piles in the vicinity points to waste being tipped directly into the sea (Richards 2007:35). Llaneilian quarry, given its age and coastal location, makes a good comparative example for possible coastal quarry sites near the Ferryland plantation.

Figure 12: The weathered face and large horizontal adit of Tyllau-Duon quarry as seen from the water. Photo courtesy of David Jones.

Pen-y-Fridd quarry was the next site, touted as "probably the oldest underground slate working in Wales" (Richards 2007:107). The land was in fact owned by the Wynne family — perhaps very distant descendants of Governor Wynne — up until the mid 19th

Figure 13: A chamber of Pen-y-Fridd which has been "worked home" to the surface. A dangerously narrow pillar can be seen in the background, and large amounts of rubble from roof collapses are in the foreground.

century; it was leased to various companies from 1813 onwards and worked sporadically up until the early 20th century (Lewis 2003:16). Located east of Blaenau Ffestiniog, the now heavily-forested site features large open caverns cut into the cliffside, the products of which are said to have been exploited since at least the 18th century (Richards 2007:107). No tools or evidence of industrial activity remains at the site, save for a few instances of 19th-century graffiti, due to the large amounts of fallen rock and roof collapses (see Figure 13). The financial failure of Pen-y-Fridd and its current state of deterioration is not surprising given the poor quality of the rock; much of what we found on site was soft, friable and riddled with pyritic inclusions. While not much of the working faces remained, Pen-y-Fridd proved to be an interesting example of early underground chambering, complete with precariously thin pillars, as well as having an interesting tie to the Wynne family.

The Rhiwbach slate mine, also located in the vicinity of Blaenau Ffestiniog, was heavily worked in the 19th century and a number of both aboveground mill buildings and underground workings remain. In contrast to the sites visited prior to this, Rhiwbach was heavily mechanised and was served by a dedicated tramway and the Ffestiniog railway in order to transport material (Richards 2007:200-201). A massive slate incline rises up over the mill buildings, some of which featured the remnants of slab saws and mechanical dressing machines. The entirety of the site is surrounded by mountains of tipped waste, a testament to its peak output of over 8000 tons of material per year during the late 1860s (Richards 2007:200; see Figure 14). The Rhiwbach property also features the remnants of social activities: the ruins of the manager's house, a schoolhouse/chapel and even lavatory buildings remain. The underground workings feature 8 levels of pillared galleries, the lowest of which is flooded. Although the mill buildings were powered by steam, artifacts within the underground galleries suggest that some level of hand-working was still taking place during its early years. Two discarded *jympars* were found, alongside everyday refuse like clay pipe bowls, liquor bottles and hobnail shoes. A slate tally chart was also found, with the initials of quarrymen etched across the top and numbers arranged in columns below, potentially denoting the amount of material extracted by each quarryman. Evidence of mechanical drill use is also apparent within some of the chambers; while *jympars* tended to have rounded shafts, some of the charge holes at Rhiwbach were more triangular in nature and thus are consistent with the shape of mechanical drill bits. These charge holes date to after 1902, when the steam engine which powered the mills also began powering an air compressor (Lindsay 1974:161).

Figure 14: The tipping piles and mill buildings of Rhiwbach as seen from the quarry incline.

The final quarry visited on the trip was Cwm Orthin, located near the town of Tanygrisiau. Work at this site began in 1810 as an open-faced operation, but quickly transitioned to a large-scale underground quarry due to the low angles of the veins (Richards 1999:156). Like Rhiwbach, Cwm Orthin began as an unmechanised venture but soon constructed mills which were powered by water wheels and, later, steam (Richards 2007:156). The twelve levels of underground workings are immense, forming a sprawling labyrinth of pillared chambers (see Figure 15) so vast and numerous that it is rumoured by locals to have inspired J. R. R. Tolkien's vision of the Mines of Moria. By the end of the 19th century Cwm Orthin was joined to the nearby Oakeley quarry, the workings of the two having slowly encroached upon each other over time, further expanding the site. The through-trip of both quarries required a minimum of 8 hours in order to see all of the material remains the site has to offer, of which there are many: hats, hobnail boots, marmalade jars, tobacco pipe stems, teacups, liquor bottles, mine carts and even sticks of Alfred Nobel brand explosives littered the hallways and chambers. Stubs of tallow candles ascended along chamber walls to the ceiling, where ladders, chains and bridges are still affixed. In some chambers iron pegs are still visible, driven into the side walls in a stepwise fashion; these were used like a rudimentary staircase by the quarrymen to reach the top of working faces. Hobnail boot prints can also still be seen in the mud on some levels.

Figure 15: One of the tall chambers of Cwm Orthin, with a workers' *caban* in the foreground. Photo by Paul Doutch.

Overall, Tyllau-Duon and Pen-y-Fridd provided the most relevant information for this project. Although Rhiwbach and Cwm Orthin were both interesting from a social and archaeological perspective, they were both more modern underground quarries which used steam and electrical power. Along with Vivian Quarry at the Llanberis Museum, both Tyllau-Duon and Pen-y-Fridd provide examples of hand-worked galleries and chambers, with the former being a great analog for early seaside quarrying in

Newfoundland. Pen-y-Fridd's interesting tie to the Wynne family aside, it also proved to be an exemplar of heavily deteriorated quarrying as a result of poor material, a case which could very well ring true in the vicinity of the Ferryland plantation.

Figure 16: The fruits of our labour: a tile made from the material collected at Rhiwbach quarry, with a punctured nail hole at the top.

3.2.3: Experimental Tile Making

Knowing that the material from around Ferryland would be full of inclusions and difficult to work with, myself and a volunteer took it upon ourselves to collect stone from Pen-y-Fridd and Rhiwbach in order to attempt splitting, trimming and finishing tiles. Being complete novices, this small instance of experimental archaeology was proposed in the hopes that it could also inform the ways in which skill and material quality interact to form the final product.

Figure 17: An unfinished slate from the Pen-y-Fridd quarry, with visible pyrite inclusions.

The Rhiwbach material was brought back to the quarrymen in Llanberis, who remarked that it was full of inclusions and likely wouldn't split properly. True to their word, the sheet broke at a bevel that ran across the face of the block, resulting in large, angular pieces and an incomplete sheet. Once split down to the correct thickness, however, the Rhiwbach material trimmed well (even if it was a very unusually sized slate) and could even withstand the force of being punctured with the roofer's hammer for a nail hole (see Figure 16). The Pen-y-Fridd material, on the other hand, was difficult through and through. Due to its soft and friable nature, sheets were difficult to split from the block. Trimming resulted in breakage and crumbling edges, while punching nail holes often shattered the top half of the sheet. The waste that resulted from working the Pen-y-Fridd material resembled the tiny pieces created during trimming stages, while the large angular waste from splitting the Rhiwbach stone against an inclusion was almost indistinguishable from stone which fractures naturally due to freeze-thaw cycles.

As mentioned previously, lower quality stone requires more skill to produce a suitable tile. The Rhiwbach material, coming from an Ordovician deposit, was of decent quality save for the inclusions running through it and thus was easier to work with. While slates were indeed made from the Pen-y-Fridd material — many unfinished ones were found around the defunct quarry site (see Figure 17) — our lack of skill became apparent when working such difficult stone. This small-scale experiment supports the claim of the Llanberis quarrymen: the 17th-century slaters of Ferryland must have had some degree of skill and experience to make useable tile from the unpredictable local shale.

3.3: The Search for Wynne's Quarry

3.3.1: Overland Hikes

In June of 2018 a number of scouting and surveying trips were planned to assess the coastline from Broom Cove in Aquaforte to Broad Cove in Calvert, covering roughly 7km by both land and sea. However, only the northern half of this range was surveyed as ongoing property disputes made access to the southern stretch from Ferryland to Aquaforte exceedingly difficult. Several overland hikes were undertaken between Ferryland and Calvert to mark notable shale outcrops; this endeavour produced three new potential quarry sites in addition to those previously identified by Gaulton (1997:28-30; see Figure 18). Of note was the complete lack of quarry refuse or tipping piles, which are commonplace in quarry settings, along the entire stretch of coastline. These pedestrian surveys also failed to produce any historical artifacts.

The shale-bearing hills behind the colony site — an area known colloquially as "The Gaze" due its fantastic view of the area — was also an area of close investigation. Given the Welsh propensity to mine slate from mountains and hillsides, and its proximity to the colony site, these hills may have served as a potential source of material. After a full day of traversing its cliffs, it was concluded that while the shale could be pulled from the cliff face by hand it rendered only poor quality material unsuitable for tile manufacturing. Moreover, this area bore no telltale signs of quarrying activity and also failed to produce any historical artifacts.

Figure 18: Map showing the locations of previously proposed quarry sites as well as potential sites discovered during the project's surveying trips.

3.3.2: From the Water

Using the GPS points collected during our overland hikes, a student volunteer and I decided to approach possible quarry locations from the water, as the early colonists would have. Canoeing from Ferryland to Calvert Bay, we covered roughly 5km of coastline and located several of the previously proposed quarrying spots. While they all had an abundance of decent quality material, many of these locations appeared to be both small in scale and any possible "terracing" in the stone mentioned in previous literature appeared to have been caused by natural erosion. One particular location which we had identified during our overland hikes, situated directly behind Baltimore School in Ferryland, looked significantly more promising when viewed from the water. Its shape and form deviated from anything else we had seen along the coastline that day. This area featured an approximately 35 metre wide, square cut into the landmass, with two visible terraces of stone along its vertical face (see Figure 19).

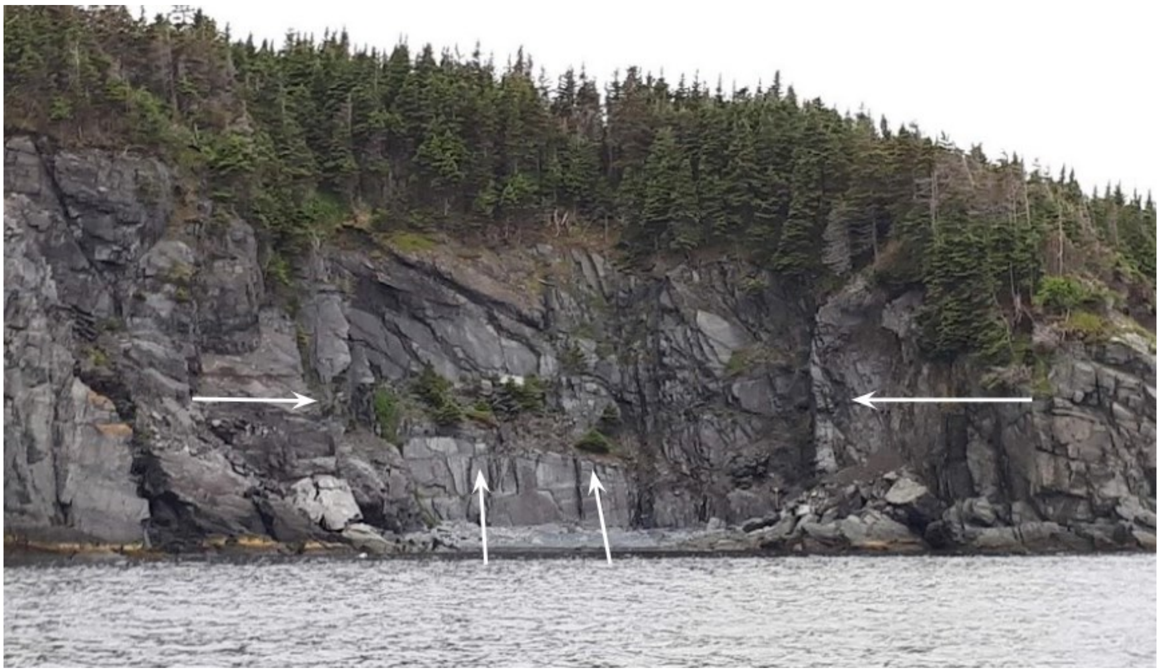

Figure 19: Potential historic quarrying site as seen from the water. The cuts into the landform and the possible terracing have been highlighted with arrows.

Upon further inspection, the material appeared to be of good quality and had a near-vertical cleavage plane, meaning that quarrymen could simply pry whole slabs of shale from the face without much effort. Surface finds were limited to the expected modern-day refuse carried in by the sea and by terrestrial visitors, so we set about digging a small shovel test halfway between the shore and the rock face to assess the site's archaeology. Unfortunately, water began to seep up through the sand faster than we could clear it at a depth of around 40cm, still well within the beach deposit layer that had sand, rounded pebbles, beach glass and a mixture of both modern and early historical refuse (see Figure 20). Before departing from this particular spot, however, a large slab of stone partially buried on the beach caught my eye. One edge is completely smooth and straight, with the edge running against the diagonal bedding plane of the stone, suggesting that such a clean face was not produced naturally. Without any context or datable material, however, this slab is more of a tantalizing hint than a smoking gun (see Figure 21). Samples of slate from this potential quarry match the material of Ferryland's roof slates, both having been sourced from the St. John's Group[3] (King 1988). Despite the lack of material finds, the site's proximity to the colony, the quality and orientation of the stone and the site's overall size and form make it an excellent candidate for the location of Wynne's quarry.

Knowing the size and location of this probable quarry allows for some speculation on how the site would have operated in the 17th century. Workings at this site were likely rudimentary in nature, utilizing prybars and chisels to separate blocks from the face. A simple system of pulleys or counter-balanced cranes, like those used in France at the beginning of the 18th century, could have been used to safely lower blocks from upper galleries or hoist blocks into a docked vessel (see section 2.3.2 and the plates in Figure 5). Sledges on wooden tracks, driven entirely by manpower, would have been the most resource-efficient way to transport stone a short distance from the quarry face to a nearby wharf or quay. The colony site lies only two kilometres away from this quarry, but Wynne's quarrymen would have had to contend with ragged coastlines and rough surf.

[3] The St. John's Group is a group of geological formations laid down during the Ediacaran Period (ca. 635-542 MYA). It is characterized by a predominance of shale and fossils such as those from the *Aspidella* genus (King 1988).

Flat-bottomed *bateau*-style boats like the 18th-century example from Llyn Padarn (discussed in section 3.2.1) are well-suited to transporting cargo across lakes and down rivers as their flat bottoms and low freeboard[4] allow for easy docking and loading/unloading (Illsley and Roberts 1979:49). The suitability of these lake-going vessels for transporting stone across open ocean is questionable: the Llyn Padarn boat sank carrying only 1.85 tons of slate in relatively calm and shallow waters (Illsley and Roberts 1979:47). A larger, clinker-built vessel such as the 16th-century wreck found in the Welsh Menai Strait is a more likely candidate for such a job (Roberts 1979:249). The Pwll Fanog shipwreck is approximately 10 metres long and sank in the latter half of the 16th century with 20 tons of slate cargo on board (Fenwick and Gale 1998:120-121). Although more complicated in their construction, these larger, sturdier vessels would have been better suited to transporting several tons of unprocessed stone along the coast and into the colony's harbour.


Figure 20 (left): Potential quarry site test pit during excavation. Figure 21 (right): Potentially cut or split slab on the beach.

[4] The distance from the waterline to the top of the vessel's hull.

Figure 22: A photo of the forge in Area B, facing south. The test pits surrounding the feature can be seen in the background.

3.4: Ferryland Excavations

3.4.1: Forge (Area B)

The 17th-century forge, which was excavated in the 1990s (Carter 1997) and has now been incorporated into the public programming of the site, was one area of fairly intensive investigation. Ten half-metre test pits were sunk along the east, south and west hillsides of the forge in a checkerboard pattern with the hopes of finding a discreet deposit from the construction phase of the structure (i.e. the early 1620s; see Figure 22). Unfortunately, the stratigraphy in the pits consisted primarily of churned up and redeposited fill, interspersed with beach cobbles, slag and charcoal, an occurrence which is likely due to the construction and subsequent destruction of nearby modern houses and outbuildings directly south of the forge. A test pit from Carter's (1997:32) previous investigations was also found (along with some old field tags from the early 1990s!) and it is safe to assume that the installation of interpretive features have also resulted in a fair amount of soil disturbance surrounding the forge. Only one seemingly discrete event, which consistently contained artifacts from the 18th century, was identified in the most northeastern of the test pits. This layer extended from a depth of 48cm down to 90cm and appeared to directly overlay subsoil. The rest of the pits produced artifacts from a range of over 300 years, with 17th-century pipe bowl fragments found alongside modern refuse. Given the wealth of material found by Carter (1997) during his research, it is no surprise that traces of 17th-century activity can be found within modern fill. The presence of small pieces of shale within these disturbed layers is notable however, due to the fact that the colony sits on a geological formation known as the Ferryland Head, which does not naturally contain shale or slate as part of its bedrock (King 1988). The presence of these pieces therefore immediately points to cultural activity surrounding the forge, but without any context their occurrence does not say anything conclusive about the presence of nearby tile manufacturing.

3.4.2: Builder's Trench (Area F)

During the construction phase of Lord Baltimore's mansion house during the early-to-mid 1620s, workers cut into the hillside to place the footing stones of the rear wall and create space to work, filling in the resulting trench upon completion. The result is a discrete deposit of construction debris that is directly associated with the construction of the mansion house. Previous excavations in the builder's trench, which runs east-west behind the south wall of the mansion house, have revealed a >30cm thick deposit of slate waste associated with the manufacturing of the structure's roof tiles (Gaulton and Hawkins 2014:54-55). With the assistance of my volunteer crew we opened a third set of units within the builder's trench in order to assess the extent of the slate deposit and potentially collect samples. Our trench, which was a single metre wide and five metres long, was immediately east of previously dug trenches and extended south from the rear wall of the mansion house. The team worked laboriously to dig through a two metre layer of fill and slope wash before reaching Event 920, a dark, sandy layer which was scarcely 5cm thick (see Figure 23). The stratigraphy in the northernmost unit, closest to the wall, had a great deal of disturbance from previous excavations in the 1990s which had dug down to the footing stones of the wall. Event 920 was present in the units to the south, further up the hill, and predominantly featured construction debris like lime, charcoal, brick and window glass. A small number of Portugese redware and North Devon coarse earthenware sherds were also present, as were a few handfuls of slate pieces along with a single tile fragment. The layer thinned out to subsoil in the southernmost unit, which sloped sharply uphill. While we had hoped to find the continuation of the deposit of slate waste present to the west, there was very little slate present in our trench. These investigations support the notion that the slate deposit was thickest at the western edge of the builder's trench, near the corner of the building, and tapers out as it continues east along the rear wall of the building. The fact that such a large deposit is present at all still suggests that at least some stages of tile manufacturing were taking place to the south of the structure in the 1620s. The location of the deposit, so close to the corner of the building, leads one to wonder if a second similar deposit may be present on the eastern edge of the mansion house. While testing this hypothesis was not possible due to our short field season, future investigations in the builder's trench may provide an answer.

Figure 23: The trench to the south of the mansion house in Area D, with the dark early 1620s layer exposed under two metres of overburden.

3.4.3: Feature 217 (Area D)

The final area of investigation concentrated primarily on the south side of Feature 217, a clay-bonded masonry structure dating to the 1620s. The interior of this structure contained a collapse/destruction layer of slate roof tiles directly overlying a dirt floor which was capped off by a thick layer of wall rubble. The stratigraphy suggests the heavy stone roof collapsed inward before the rest of the building came tumbling down on top of it. A 2x4 metre trench, with later 1x1 metre extensions in the southeast and northwest corners, was placed over and adjacent to a previously-dug half metre test trench which contained a thick deposit of slate chips (Gaulton and Hawkins 2017:61-63; Lacy 2017:185-186). While the southernmost units were shallow and contained only disturbed soil, we had the incredible luck of locating the southern wall of Feature 217 within the northernmost units of this trench (see Figure 24). Shortly afterward we managed to locate Lacy's (2017:186) backfilled test trench. Roughly three metres south of the wall, expanding out from Lacy's (2017:186) trench, we hit a dense deposit of slate chips from which we collected two full buckets of bulk samples. This deposit sloped downhill to the north where it transitioned into a layer of larger tile fragments, some of which were complete or near-complete with the exception of breaks along the tops or bottoms. This deposit of tile fragments and smaller chips, which ran up against the wall, was interspersed with 17^{th}-century ceramics like West Somerset earthenware.

Figure 24: The exposed south wall of Feature 217, facing north. The partially-excavated Feature 217 can be seen in the background.

Much like with the mansion house, the archaeology adjacent to the south wall of Feature 217 clearly demonstrates that the early colonists cut into the hillside, creating a small builder's trench, in order to prepare a level surface upon which to lay the footing stones of the structure. The exact size of this trench was difficult to discern as the fill very closely resembled subsoil, differing only in density. The presence of slate tile fragments and debris down through the trench and alongside the wall's lower courses and footing stones firmly places it within the timeframe of the building's construction (i.e. the early-to-mid 1620s). The slate fragments within this 17th-century deposit also bore the tell-tale signs of tool use, mirroring those seen in the quarrymen's experimental tile manufacturing in Wales: beautifully dressed edges, diamond-shaped pick holes from punching the slates with a roofer's hammer, and long, thin "chop" marks from a bladed tool known as a slater's

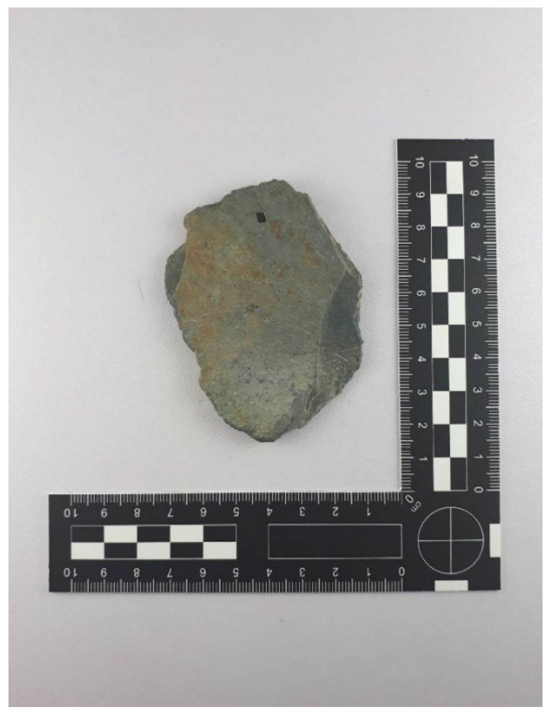

Figure 25 (top): A piece of slate manufacturing debris featuring a long, thin chop mark from a slater's knife. Figure 26 (bottom): Another slate chip from Area D featuring a diamond-shaped pick mark from a roofer's hammer.

knife (see Figures 25 and 26). The section drawings for these units can be seen in Appendix B.

Much to our surprise and delight, a second concentration of slate chips and broken tiles was discovered near the northwestern corner of the structure underlying a layer of occupation debris (see Figure 27). It perfectly mirrors the deposit to the south, consisting entirely of chips and tiles which appear to have been broken during manufacturing. While it is possible that the workman/workmen simply moved to the other side of the structure after one pitch of the roof was tiled, Wynne's letter also suggests an alternative interpretation in his request for "a slator *or two*" (Wynne 1622b, emphasis added). The presence of two deposits, one on each side of the building, also strengthens the hypothesis that additional slate deposits may yet be found at the south-eastern or north-western corners of the mansion house in Area F.

Figure 27: The second deposit of slate manufacturing debris located to the north of Feature 217. This deposit perfectly mirrors the deposit to the south. Inset: A close-up of the fine slate chips within the deposit.

3.4.4: Waterfront Premises (Area C)

While it was originally planned to excavate in the vicinity of the storehouse in Area C, investigations in this area were dismissed due to a number of factors, one of them being the limited amount of time left in the field season. Previous excavations revealed that the entirety of the premises was built upon reclaimed land comprised of deep layers of fill, making such an endeavour time consuming and the identification of discrete deposits difficult (Gaulton 1997:45-46). Moreover, the nearby modern road overlays much of the area and likely also rests on top of archaeological deposits related to the construction of the buildings in Area C.

3.5: Post-Excavation Analysis

3.5.1: Artifacts and Tile Fragments

Following excavation, all retrieved artifacts and tile fragments were washed, labelled and catalogued. Over 1,500 partial tiles were recovered from the units in Area D alone. While some of these were initially believed to be part of the debris spread from the collapse of Feature 217, it became obvious that this was not the case. The tiles which were found within the structure, and therefore most certainly from its collapse, while heavily fragmented, still had all of their pieces in situ. During the course of both excavation and post-excavation analysis, it became obvious that almost none of the tiles outside the structure were complete, being comprised of only a bottom half (the "tail") divorced from its top, or vice-versa. Even tiles which appeared to be complete or near-complete had defects that in some way rendered them unusable: some had broken nail holes, while others had nail holes which were too close to the edge of the tile. Several were simply too thick to be effective, likely due to the difficult nature of the stone, while others exhibited hairline fractures which would have resulted in leaking and breakage. Moreover, none of the surviving nail holes from our units in Area D (of which there were few) showed any signs of iron corrosion, unlike tiles found elsewhere on the site. Iron corrosion indicates use, as nails were sometimes used to fasten tiles to roofs in Ferryland. These facts, along with the stratigraphy discussed above, supports the notion that the tile fragments found around Feature 217 were broken during manufacturing prior to the structure's collapse.

3.5.2: Slate Chip Analysis

As previously stated, bulk samples of slate chips were taken during the 2018 field season from both the south (unit E130S9) and north (unit E130N0) deposits surrounding Feature 217 in Area D. These two samples were collected by scooping the top 5cm of the deposit directly into buckets in an effort to minimize sampling bias. A sample collected in 2014 from the builder's trench in Area F (unit E59S9) was retrieved from storage for the purpose of analysis. Given that the sample was collected many years ago the possibility of sampling bias cannot be dismissed. These historical deposits were compared against sample chips collected in Wales during the final dressing/trimming stages of modern Welsh tile manufacturing.

Chips and fragments from these samples were weighed using an Ohaus CS Series digital scale, which unfortunately only had an accuracy of whole grams. Pieces which weighed less than a gram were therefore recorded as zero. To help compensate for the potential issues caused by the weight values, the length and width of the chips were also measured using digital calipers and from this data approximate surface area values were calculated. These values are summarized below in Table 1.

Sample source (unit/location)	Sample size	Mean weight (g)	Mean length (mm)	Mean width (mm)	Mean surface area (mm)
Ferryland Area D E130N0	n = 899	7.35	36.51	21.63	982.13
Ferryland Area D E130S9	n = 899	11.66	41.14	25.68	1372.64
Ferryland Area F E59S9	n = 899	6.09	34.42	20.72	870.62
Welsh sample	n = 429	2.53	32.22	14.49	509.78

Table 1: Slate chip sample sizes and mean measurements.

While it was assumed that multiple stages of tile manufacturing would produce histograms with multiple "peaks" (i.e., multiple means), there is a lack of apparent discrete groups and the data overwhelmingly shows a prevalence for smaller pieces (see Figures. 28, 29 and 30). Moreover, the histograms from the Ferryland samples resemble that of the Welsh sample, which was collected from a single stage of processing (i.e. the trimming stage). A cursory glance at the data in Table 1, however, shows that all of the means from the Ferryland samples are larger than those of the modern Welsh sample, but statistical analysis is necessary in order to determine if the perceived differences are indeed significant. The histograms of these values across all samples are strongly skewed to the right, showcasing a log-normal distribution. Log-transformation of the surface area values was used to achieve a more normal distribution so that standard parametric tests could be applied (see Figures 28, 29 and 30). The weight measurements could not be treated in such a fashion due to the occurrence of 0g measurements, and as a result only the means of the surface area measurements could be tested.

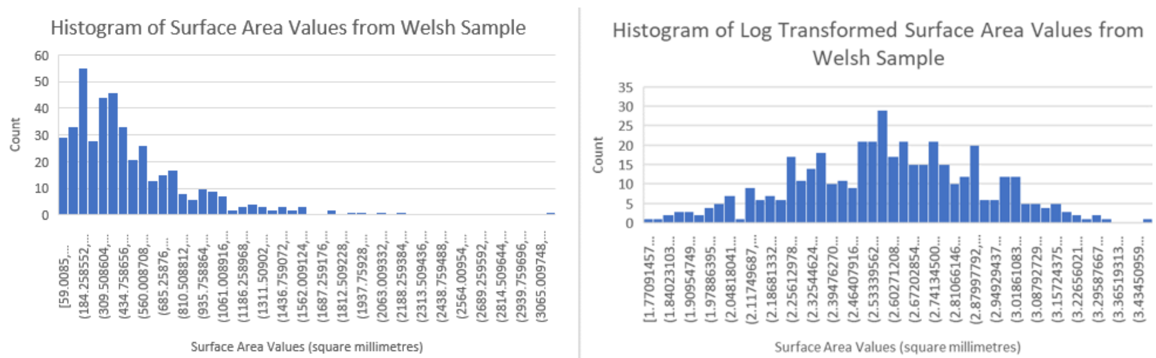

Figure 28: Histograms derived from the surface area values of the Welsh sample before (left) and after (right) log transformation.

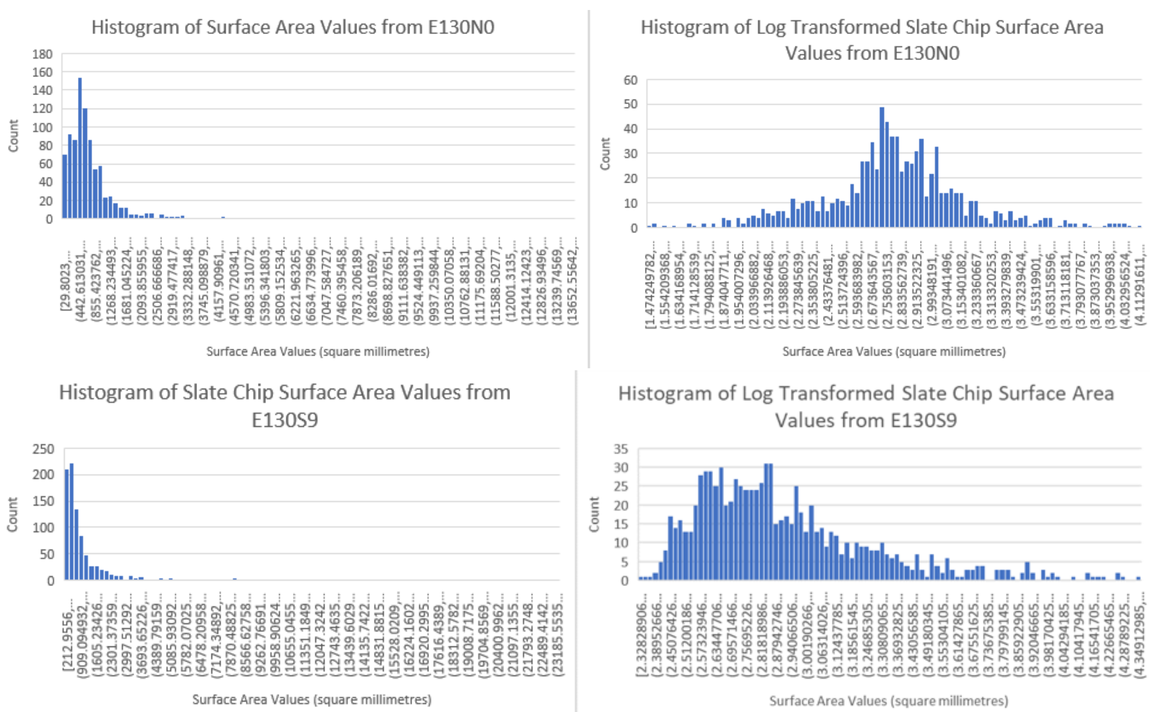

Figure 29: Histograms derived from the surface area values of the Area D samples before (left) and after (right) log transformation.

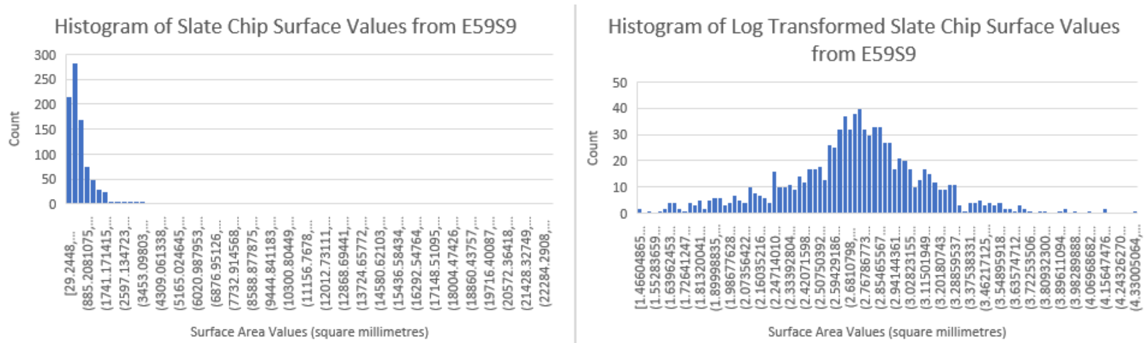

Figure 30: Histograms derived from the surface area values of the Area F sample before (left) and after (right) log transformation.

Given that the sample sizes and variances are unequal, a Welch's t-test for unequal variances was used to explore these differences. All transformations and tests were performed using Microsoft Excel. In all instances the log-transformation base was 10, the null hypothesis assumes no difference between the means and $\alpha = 0.05$. The results of the Welch's t-tests (Tables 2-3) are as follows:

	E130N0 (AREA D)		**E130S9 (AREA D)**	
	Ferryland Sample Surface Area (mm)	**Welsh Sample Surface Area (mm)**	**Ferryland Sample Surface Area (mm)**	**Welsh Sample Surface Area (mm)**
Mean	2.795245	2.59824	2.924345	2.59824
Variance	0.156099	0.098235	0.132501	0.098235
Observations	899	429	899	429
df	1039		966	
t	9.818089		16.80921	
***p* (two-tail)**	8.08E-22		8.14E-56	

Table 2: T-test results for the log-transformed surface area measurements from samples drawn in Area D.

	E59S9 (AREA F)	
	Ferryland Sample Surface Area (mm)	**Welsh Sample Surface Area (mm)**
Mean	2.725981	2.59824
Variance	0.174721	0.098235
Observations	899	429
df	1089	
t	6.208501	
***p* (two-tail)**	7.59E-10	

Table 3: T-test results for the log-transformed surface area measurements from samples drawn in Area F (builder's trench).

Given that $p < 0.05$ in all cases, the perceived differences between the means of the Ferryland samples and the Welsh samples are indeed significant. The interpretation of this data, and the conclusions which can be drawn from the fieldwork outlined in this chapter as a whole will be discussed in Chapter 6.

Chapter 4

Transatlantic Traditions: The History of Welsh Quarrying and its Connections to Newfoundland Slate

> This chapter was co-authored with Johanna Cole, an undergraduate volunteer who assisted with the fieldwork discussed herein. Her contributions are featured in section 4.3. An edited version of this chapter has been submitted for publication to an upcoming special volume of Northeast Historical Archaeology.

Investigations at the plantation site of Ferryland, Newfoundland have shown that the presence of Welshmen has co-occurred with the practice of local slate quarrying since the early colonial ventures of the 17th century. Welsh culture in Newfoundland experienced a resurgence in the 19th century, when a number of small slate quarries were established overlooking both the Bay of Islands on the west coast and Smith Sound in Trinity Bay. Just as they did in the 17th century, Welshmen brought with them a culturally-influenced familiarity with slate quarrying and splitting in the 19th century. The following chapter outlines the history of these Newfoundland quarries, as well as the social, political and economic factors which encouraged the migration of Welsh quarrymen across the Atlantic to remote and isolated areas of the island. The working conditions of Welsh quarries and the labour disputes which dominated the late 19th century, discussed below, had a direct impact on Newfoundland's fledgling slate industry, driving veteran Welsh quarrymen from their mountains in hopes of finding greener pastures. Newfoundland's brief but intensive quarrying activity of the 19th and 20th centuries left indelible marks on the Trinity Bay landscape, and this chapter concludes by outlining preliminary explorations of archaeological remains near the town of Hickman's Harbour on Random Island.

4.1: History of the Welsh Slate Industry

4.1.1: Growth and the "Golden Years"

Prior to the late 18th century slate quarrying in Wales primarily supplied a local market, with men leasing land to quarry and split slates for personal use and limited sale rather than industrial-scale exportation (Lindsay 1974:22-24). The relative remoteness of North Wales, which became the epicentre of slate quarrying, and a lack of infrastructure made long-distance trade both difficult and costly. In spite of these challenges, the Industrial Revolution began a building boom and by the 1780s there was increasing demand for materials, including slate tiles and slabs (Jones 1981:14). While the stone of Penrhyn Quarry, which grew to become the largest commercial Welsh quarry, had been worked since the 16th century, it was not until Richard Pennant, the Baron Penrhyn of Penrhyn, took over his late father's estate in 1782 that quarrying for the purpose of sale and exportation began in earnest (Richards 2007:31). Throughout the 1780s Lord Penrhyn began purchasing adjacent properties for the purpose of expanding his holdings in addition to beginning a number of infrastructure projects (Lindsay 1974:46, 48-49). As operations expanded the gallery system was adopted, in which material was extracted in benches or steps cut into the cliffside, in order to allow for more organised and expedient removal of stone (Gwyn 2015:54; Richards 2007:31; see Figure 31). By 1790 a small inlet near the town of Bangor, situated on the Menai Strait roughly seven miles from the quarry, had been converted into "a commodious harbour" now known as Port Penrhyn, and a railway from the quarry to the port was completed by 1801 (Lindsay 1974:48). Trains consisted of horse-drawn carriages linked together, carting up to 24 tons of slate each journey from the gallery face down to the port (Lindsay 1974:48). It was at the port that the material was either converted into writing slates at a nearby factory or hand-loaded onto ships bound for Ireland, Liverpool, Bristol or London (Lindsay 1974:48-49; Richards 2007:31).

Figure 31: A lithographic print of Penrhyn Quarry by Alfred Sumners, dated to the mid-19th century (Amgueddfa Cymru/National Museum Wales).

The Dinorwic Quarry, second in size only to Penrhyn, began in much the same manner. Small quarries leased by local workers were taken over in 1787 by Lord Thomas Assheton Smith and his partners Thomas Wright, Hugh Ellis, and William Bridge

(Lindsay 1974:56; Richards 2007:48). While Assheton Smith built an incline and began the process of repairing nearby roads, slate was transported by sledge within the quarry itself, then transported by boat across Llyn Padarn and carted to the newly-constructed Port Dinorwic (Richards 2007:48). While infrastructure at Port Dinorwic was completed in 1793, was not until 1824 that the Dinorwic Railway linked the port to the quarry (Lindsay 1974:60). Quarries in Nantle and Ffestiniog shared much the same narrative: wealthy aristocracy, realising the untapped value of their lands, bought out local leases, made necessary improvements to the local infrastructure and began exporting the slates which would roof the buildings for the Industrial Revolution.

With the abolishment of the slate tax in 1831 came a boom in the industry, encouraged by the high price of timber and the ever-increasing population of Europe (Lindsay 1974:117). Penrhyn, Dinorwic, and other large quarries like Dorothea in the Nantlle Valley and the Oakeley workings in Blaenau Ffestiniog continued to grow, spurring further infrastructure development in what was considered to be a remote and isolated area of Britain (Lindsay 1974:11-13). The Ffestiniog Railway became operational in 1836, purpose-built on its own narrow gauge line to transport slate from the Ffestiniog quarries to the newly-improved harbour in Porthmadog (Gwyn 2015:233). The Great Fire of Hamburg in 1842 fortuitously led to increasing demand for slates in continental Europe, and markets in France, Norway, Sweden, and Denmark also continued to grow throughout the following decades (Gwyn 2015:31). Roads, railways, mill buildings, barracks and indeed even entire towns began to spring up in and around the quarries of North Wales, employing nearly 20,000 men at its peak (Gwyn 2015:26;

Lindsay 1974:11-12). By the 1870s both Dinorwic and Penrhyn quarries had outputs that exceeded 100,000 tons per annum and profits equally as high (Richards 2007:31, 49).

Despite the lucrative nature of the industry, day-to-day life for quarrymen was often uncomfortable, dangerous and, sadly, quite short. Many were fatigued by the time they even reached the quarry face, having to wake early each day to walk several miles to work. Those who were able to take trains or ferries fared no better, with one doctor's report calling the crowded, open-sided trains "pneumonia traps", describing the men as "hanging about wet for hours at the station" and being "treated more like animals than human beings" (Jones 1981:31). In more remote areas the men lived in barracks from Monday until Saturday afternoon, travelling home to spend Sunday with family; the conditions of these company-provided accommodations are often described as being cramped, cold and squalid (Gwyn 2015:180). Reports from Blaenau Ffestiniog describe overcrowding, such that in some places people were sleeping three to a bed; workers also had to endure poor ventilation, dirty water "not fit for culinary purposes" and the "extreme virulence" of illnesses like typhoid fever (Jones 1981:27). Those who built their own cottages nearby may have had more space, but the ground rent charged by the quarry owners often left them penniless and the rocky mountain slopes upon which they lived meant that there was little in the way of agriculture (Jones 1981:19-20). Despite the fact that many financed and built their homes themselves, cottagers situated on quarry property could be evicted without notice; at the end of their tenancy the land and the structures built on it became property of the quarry owner (Jones 1981:26-27; Lindsay 1974:65). Sanitation at quarry sites was rudimentary at best, with only a small number of privies to serve workforces that sometimes numbered in the thousands (Gwyn 2015:172).

Concern also grew amongst doctors and quarry managers about the diet that quarrymen kept: tea with bread and butter was the daily staple, with some quarrymen only having meat and vegetables during their weekly visit home on Sundays (Jones 1981:32). The work itself was hard and dangerous, with falls and machinery-related accidents leading some quarries like Dinorwic to open their own hospitals (Gwyn 2015:174). Even these quarry-managed hospitals were looked upon with distrust by some of the workers, as the doctors' independence was often questioned due to the fact that they were hired by the quarry owners. This distrust was not without merit: in one instance a doctor at Dinorwic changed the cause of death of one worker from injuries received from a fall to "syncope", or fainting, presumably to affect compensation and pensions to his widow (Jones 1981:40). Respiratory disease amongst quarrymen, now recognized as silicosis, was rampant but vehemently denied by quarry officials (Gwyn 2015:174). The slate dust that accumulated in the rows of *gwaliau* (splitting sheds), and later produced by percussive drills and slab saws in mechanised mills wreaked havoc upon the lungs of quarrymen. Despite the fact that nearly half of all recorded male deaths in Blaenau Ffestiniog were due to respiratory disease, Dr. Mills Roberts of Dinorwic wrote in 1893 that the issue was "best left alone" (Jones 1981:41). For all of their struggle, the quarrymen were not well-paid, especially when one considers that they had fees for medical care, transport and rent taken from their paychecks (Gwyn 2015:167; Lindsay 1974:61-62). Money was also deducted to help quarries cover the cost of slates broken during handling and shipping, presumably because this was due to negligence on the quarryman's part (Carwyn Jones, pers. comm., 31 May 2018; Jones 1981:39). Wages were so low that gallery managers struggled to keep the same quarrymen for any length of time, since "even a few pence or a shilling more would be sufficient to encourage men to move" (Lindsay 1974:62). In this way the quarryman was also often transient, moving from quarry to quarry depending on who offered the best wages and the steadiest work.

4.1.2: Industrial Unrest, Instability and Decline

Given the low wages, poor health and overall difficulty of a quarryman's job, it's no surprise that workers began to grow unhappy with the way quarries were managed during the last quarter of the 19^{th} century. Small strikes in 1874 at both Penrhyn and Dinorwic ended in victory for the newly-established North Wales Quarrymen's Union (NWQU), but the prosperity of previous decades began to decline shortly thereafter (Jones 1981:187, 199; Lindsay 1974:246-247). A general depression in the building industry began to cut into profits by 1878, and as it continued into the 1880s quarry managers found increasingly severe ways to prevent losses: cutting wages, reducing the number of work days in a week and withholding pay for even minor infractions became common practice as the price of slates fell nearly 50% between 1877 and 1889 (Lindsay 1974:249). Allegations of favouritism, the reduction of wages, denial of holidays, increasingly strict quarry by-laws and a general dislike of management led to a short lockout at Dinorwic through late 1885 and into the early months of 1886 (North Wales Express, 18 December 1885).

In 1886, in the face of plummeting profits, Lord Penrhyn appointed a scrupulous English accountant named Emilius Alexander Young as the general manager of Penrhyn Quarry; the increasingly strict rules which followed this appointment led to growing unrest among its workers (Jones 1981:175-176). In the decade that followed Young's appointment to the quarry, the NWQU approached both him and Lord Penrhyn regarding issues of working hours, wages and overall working conditions but their demands were staunchly denied every time (Jones 1981:178-183). During this time the NWQU grew in both membership and community support, a trend which both Young and Penrhyn were determined to stop. On the 28th of September 1896 union committee members resolved to strike in March of 1897 if their demands were not met (Jones 1981:181). The very next day 57 members of the committee along with 17 other quarry workers were suspended without explanation, triggering a mass-meeting of 3,000 quarrymen who resolved to cease work until they were granted "their just and reasonable rights" (Jones 1981:186). This strike, which became known as the First Penrhyn Lockout, lasted nearly a year but ultimately resulted in very little progress. The final negotiations between committee chairs and Penrhyn management took place largely in secret, and when the men returned to work in August of 1897 their wages and terms of employment were essentially the same as when they had walked out (Jones 1981:193-195).

Resentment continued to grow in the years that followed the First Penrhyn Lockout, and frustrations were exacerbated by an increasingly unstable market. Despite a record profit of £133,000 (over £16,000,000 today with inflation) at Penrhyn in 1898, Young and Lord Penrhyn continued their campaign to divide and weaken the NWQU (Linsay 1974:255). After Young banned the collection of union dues in the quarry in April of 1900, tensions once again began to build between management and workers (Jones 1981:210). The unresolved issues from the previous strike coupled with a number of worker suspensions and internal disputes came to a head by the end of the year, and on the 22nd of November 2,800 men walked out of the quarry; over 1,000 of these men never returned to work (Jones 1981:212). The strike came to represent the struggle of Welsh culture and liberalism against the overbearing conservatism of their English masters (Gwyn 1999:50; Jones 1981:216, 226-227). A primary complaint amongst the workers was the banning of traditional customs and the denial of time off for traditional Welsh holidays, a fact that is unsurprising given Young's general dislike of Welsh people and his opinion that they were "childish and ignorant" (Jones 1981:224). The lack of respect from management was an acute issue throughout the strike, with many quarrymen feeling that their treatment at the hands of Young and Penhryn was degrading: "The burden of their complaint is the spirit of their treatment. 'Let us be treated like men' is the supreme form of their demand" (London Daily News, 8 January 1901).

The onset of the Second Boer War between the British and the Dutch in 1901 led to a general economic depression across Europe, and this only served to worsen the state of an industry which was already suffering due to the lockout of its largest quarry (Lindsay 1974:255). Quarrymen began to return to work at Penrhyn at the end of 1903, but by then the damage was done (Gwyn 2015:11). With the rising popularity of alternative roofing materials like zinc and asbestos tile and the low cost of French and American slates, the depression continued to worsen (Lindsay 1974:256-257). In the early years of the 20th century wage decreases and layoffs became the norm across all Welsh quarries, and one by one they began to close (Lindsay 1974:259). The nail in the coffin came with the breakout of the Great War in 1914. Building came to a standstill, the workforce dwindled as men left to fight and the loss of trade with Germany was crippling (Lindsay 1974:259). In 1917 the slate industry was declared "a non-essential industry" (Lindsay 1974:260). While Penrhyn quarry is still operational, employing roughly 200 men, Dinorwic succumbed to financial difficulty in 1969 after 170 years of operation (Gwyn 2015:11).

4.2: The Rise and Fall of Newfoundland Slate

4.2.1: The Eastern Quarries of Bay Roberts and Trinity Bay

The history of Newfoundland slate quarrying is closely tied to that of Wales, with the most intensive extraction beginning after the first Penhryn strike in 1896. However, the earliest instances of quarrying in Newfoundland predate the decline of the great Welsh quarries with the establishment of workings near Bay Roberts in 1847. While not much is known about this particular venture, records show that in March of that year a gentleman named Charles Bennett leased land from John Butler and allegedly employed Welsh slaters to work the holding (Evans and Dickson 2004:9). With such a small operation and an undeveloped market for slate in Canada, the quarry was shut down two years later and the quarrymen sent back across the Atlantic (Martin 1983:83). Around the same time three brothers, William, George and Jubal Carberry, began producing slates sourced from a deposit on the north side of Smith Sound in Trinity Bay (Martin 1983:83). Compared to Welsh quarries of the time, the Carberry operation was quite small: the 1857 Newfoundland Census and Return lists 55,000 slates quarried in Random Sound with a value of £175 (equivalent to roughly $34,000 CAD today). Their supply was sold largely to builders in St. John's, where a Welshman named John Currie happened upon the installation of slates in the late 1850s. Inquiring about their origin and impressed by their quality, he eventually purchased a parcel of land adjacent to the Carberry quarry in 1860 (Martin 1983:83). In 1867 John's two brothers, David and Pearce Currie, moved to

Newfoundland to aid their brother in out-performing the three Carberrys; they built a home across the sound in Britannia, on Random Island, and began actively managing their brother's quarry (Martin 1983:83). Their home, the Currie Premises, is still standing as a private residence and was designated a Registered Heritage Structure in 1997.

While the Welsh market peaked in the 1870s and subsequently began its steady decline, the Curries successfully worked their holdings in Nut Cove for nearly four decades. James Howley, a geologist and surveyor, recalled in his writings from 1869 that the men at the quarry, only "some of whom were Newfoundlanders", worked the stone with great skill, and that "long practice has enabled the men to judge at a glance what is best to do with the crude material" (1997:57-58). Interest in the area's high quality Cambrian deposit was still understated at the time, but prospects were also being explored across Smith Sound on Random Island. During the 1860s a number of small workings were opened near Hickman's Harbour by a gentleman named Charles Byrant, although little is known about their operation (Ryan et al. 2010:3). The Curries' business eventually became dominated by lumbering rather than quarrying, and in 1899 the Currie brothers sold their holdings to A.J. Harvey for $25,000 (Martin 1983:82). Harvey eventually bought out the Carberrys for a pittance, incorporated the Newfoundland Slate Company Ltd. and began the expansion of a large quarry complex in Nut Cove (Martin 1983:83). It was this sale and subsequent expansion which drew the attention of Welsh quarrymen and investors. It is no surprise that their eyes were cast so far afield, as the country's main industry was now within the grim vice of both economic instability and increasing tensions between workers and quarry owners:

> NEWFOUNDLAND. GOOD NEWS FOR QUARRYMEN. In view of the departure of a great number of the quarrymen of North Wales to the South Wales coalfields and other places during the past year, in search of employment, owing to the depletion or approaching exhaustion of several quarries, and the consequent difficulty of obtaining permanent employment for an increasing population, the following extracts from a recent issue of the "Canadian Trade Review" will be of interest to quarrymen. Speaking of the industries of Newfoundland, the "Review" says: Still more valuable will be the roofing slate industry. A large portion of the Avalon Peninsula is of the Cambrian formation, in which the best roofing slate is found. It was only towards the close of 1899 that this slate was known to possess any economic value. Attempts had been made previously to work certain quarries but without success. Now, however, that it is known the good slate quarries in North Wales are approaching exhaustion, and that no more deposits are in sight, the value of slate is rapidly advancing. There are from 15,000 to 20,000 slate workers in North Wales about whose future great anxiety is felt, as unless new fields are found they will soon be without employment. The attention of the great slate capitalists of Wales has been turned to Newfoundland, and an expert is to visit the island this year to prospect for slate.
>
> [Carnarvon and Denbigh Herald, December 14th, 1900]

This article was published three years after a conspicuously-timed presentation from William Griffith, an agent for the Canadian government, who also attempted to sell the merits of employment in Newfoundland to the disgruntled quarrymen of Penrhyn (Williams 2017:98). While there are very few Canadian accounts of the quarrymen that the Currie brothers or Harvey employed, various clues allude to a strong Welsh presence on both the north and south side of Smith Sound. Harvey employed a Welsh quarry manager, a man named Richard Williams, who oversaw both the expansion and modernisation of the Nut Cove quarry. Harvey's pay scale, allegedly much hated by native Newfoundlanders, also hints at a considerable proportion of Welsh employees: "$1 a day for Newfoundland blockcutters, $1.50 for Newfoundland slatemakers, $1.75 for Newfoundland quarrymen - and $2.50 for Welshmen working at any of these jobs"

(Martin 1983:84). This pay scale no doubt appeased the Welsh workers, who took great pride in their craft and whose labour struggles at home were fueled by persistent feelings that they were undervalued by management. The immigration of Welsh tradesmen to Newfoundland did not go unnoticed in Britain, with an article in the North Wales Express declaring that:

> "The directors of the Colonial Missionary Society in appointing the new missionary to the Random District have selected a Welsh student, Mr. David F. Davies, of Carmarthen College, *owing to the number of Welsh settlers at the slate quarries recently opened in that district.*"
>
> [July 6, 1900; emphasis added]

The appointment of Mr. Davies went beyond that of a temporary visit, with an addendum to the Carnarvon and Denbigh Herald article from December 1900 referencing Smith Sound and stating:

> The Colonial Missionary Society had this neighbourhood in view when they sent out a bilingual missionary—Rev D. F. Davies, of Carmarthen College—to settle there last summer. He is stationed on Random Island, in Smith's Sound, which is the largest of the numerous islands on the east coast, being twenty miles in length, by four in width. *The village chosen for his residence is distant three or four miles from the slate quarry, in which twenty-three Welshmen, natives of Carnarvonshire, are employed.*
>
> [Carnarvon and Denbigh Herald, December 14th, 1900; emphasis added]

Indeed, the presence of Welshmen in Random Island was considered substantial enough to warrant yet another minister to travel to Newfoundland, one Rev. D. Burford Hooke; although his visit was written as having been to visit a colony of Welsh quarrymen in

"Ramdam Bay", it is safe to assume that this is an alternate spelling of "Random" as the article describes his overseeing the induction of a Welsh minister there — most likely referring to the aforementioned arrival of Rev. Davies (The Evening Express, September 3rd, 1900).

As is true with so many instances of immigration, with the physical presence of Welshmen in Trinity Bay came the continuation of Welsh culture. Of great importance to quarryman culture in specific was the Welsh language: "The rock, it is said, does not understand English; Welsh is the quarryman's first language, and in the quarry communities the traditions of the chapel and the *eisteddfod* remain strong" (Gwyn 1999:45). The *eisteddfod* is a traditional gathering during which Welsh poetry and song is recited; small-scale versions of what is now a large annual festival took place each day in the mess-houses, or *cabans*, of Welsh quarries (Gwyn 2015:171-172). During the labour disputes which plagued the 1880s and 1890s the *caban* became a place for heated political discussion, union organisation and a safe haven for Welsh liberalism, as the use of their native tongue allowed them to converse in secret (Gwyn 1999:44-45). While the quarries of Newfoundland did not require such clandestine meetings, it seems the cultural custom of the *caban* and *eisteddfod* was also carried across the Atlantic:

> "A steady climb up the rocks of about 500 feet brought the party to the "messhouse" where meals are provided, and where most of the men live from Monday to Saturday in excellent dormitories which have been provided, and from which magnificent views of sea and land are obtained. *About twenty-five Welshmen were found here, and a hearty Welsh welcome awaited the visitors. A number of the old Welsh hymns were sung, and a pleasant hour was spent.* Among the places represented were Llanberis, Carnarvon, Bedd- gelert, Bethesda, Nant-Clwyd, and Port Dinorwic."
>
> [The Chester Courant, August 29th, 1900; emphasis added]

If newspaper articles are any indication, the Welsh language was commonly heard not only on the north side of Smith Sound but also on Random Island, where the quarrymen lived with their families. Despite any resentment born out of pay scale inequality, it would seem that the relationship between Welshmen and their Newfoundland neighbours was amicable:

> The missionary station is at Random Island, which is separated from Newfoundland by Smith's Sound. The quarry is on the main island, and is from three to four miles from the missionary station at Lance Cove. The men spend the week in barracks at the quarry, but the majority of them spend the week-end with their families in the villages on Random Island. *The old missionary chapel at Lance Cove is lent for Welsh services, after the opening of the new chapel, referred to further on. Many of the Newfoundlanders attend the Welsh service on Sunday nights in order to hear the singing of the Welshmen. A Welsh sermon is also delivered occasionally at the barracks.*
>
> [Carnarvon and Denbigh Herald, March 28th, 1902; emphasis added]

The work at the Nut Cove quarry continued until 1906, with at least 13 more Welsh quarrymen from Nantle and Llanberis having been sent to the island in April of 1905 to work Harvey's holdings (Carnarvon and Denbigh Herald, August 17 1906). By the end of 1906, however, Harvey's quarry at Nut Cove was deserted and the Welshmen who were employed there dispersed; some went back to Wales, while others found work in the fishery (Martin 1983:84). Three small quarries were also in operation on Random Island itself, and some of the Welshmen may have found work there. One quarry was located south of Hickman's Harbour across the sound, near Black Duck Cove, and was operated by a St. John's merchant named Walter Grieve for less than five years (Martin 1983:84). Two more were located near the town of Hickman's Harbour, one of which was opened by William Ellis and Sir James Winter in 1900 and supplied a small number of slates to St. John's (Evans and Dickson 2004:44). A nearby set of small prospects worked by Charles Byrant in the 1860s were sold to a Yorkshire merchant named James Allison in 1906, who lent his namesake to the third and largest of the slate quarries on Random Island (Evans and Dickson 2004:44; Martin 1983:84). These smaller quarries will be discussed further in section 4.3.

By the end of 1910 the lack of worldwide demand for slate led to the closure of all the quarries in Trinity Bay. The last shipment of slate left the island in 1910, alongside a cargo of cod liver oil. It is said that rough seas led to the barrels breaking free and rolling around the hold during its transatlantic voyage. When the ship arrived in England there was "nothing left of its slate cargo but an oil-soaked pile of dust and debris" (Martin 1983:85). Misfortune has continued to plague the slate quarrying industry at Nut Cove and Random Island since, with various attempts to revive the quarries, discussed in section 4.3, failing due to high operating costs and low demand.

4.2.2: The Western Quarries of the Bay of Islands

The attention garnered by the sale of the Curries' quarry in Nut Cove also drew Welshmen to the western side of the island of Newfoundland, where another small deposit of Cambrian slate can be found. A Welshman named Owen J. Owen leased property in 1901 from the Reid Newfoundland Company near Summerside, on the north side of the Humber Arm of the Bay of Islands (Williams 2017:101-102). After returning to Wales and managing to secure funds to operate the quarry, eight Welsh quarrymen were sent to work in Summerside in 1902 to fulfill an order of slates for the roof of St. John's railway station (Martin 1983:81; see Figure 32). The Summerside quarry was plagued by misfortune, due in part to Owen's poor management and a number of accidents. By 1904, after a fire, a number of Welsh quarrymen quitting, a land dispute with a neighbouring property owner and increasing pressure from his employer, Owen J. Owen threw in the towel and returned to Wales (Martin 1983:81-82). Work at the Summerside quarry continued until 1908 under new management, despite the alleged poor quality of the stone (Evans and Dickson 2004:44). By 1909 the Summerside quarry was abandoned, and the partially-filled order of slates meant for the St. John's railway station remained there, having never been shipped (Martin 1983:82).

Figure 32: Quarrymen at Summerside Slate Quarry, date unknown. Martin (1983) believes the man on the far right, smoking a pipe, may be Owen J. Owen. The other eight men may be the Welsh quarrymen hired to work the deposit. Reproduced with permission from the Maritime History Archive, Memorial University.

Before departing Newfoundland, Mr. Owen made claims on slate deposits near Birchy Cove on the south side of the Humber Arm, situated near a town now known as Curling. After a few failed starts, and despite his reputation, Owen managed to interest a number of English investors who leased his claims and put him to work as the quarry manager in 1906 (Martin 1983:82). An article in the local *Western Star* proudly declares that 50 men were employed there, ten of which were Welshmen, and that tram tracks, a cutting shed and a number of other improvements had either already been constructed or were expected to be erected in the following months (August 21 1901). Once again, however, Owen's management led to problems: in September of 1907 the Newfoundlanders in the quarry went on strike, protesting the fact that their wages were lower than those of their Welsh co-workers (Martin 1983:84). Relationships between Owen, his employers and the quarrymen worsened until Owen fell ill in 1908 and quarrying ceased in the early months of 1909 (Evans and Dickson 2004:11; Martin 1983:84). Once again, Owen's optimistic venture began with a bang and ended with little more than a whimper. Unlike the quarries near Trinity Bay, a revival of quarrying on the Bay of Islands has not been attempted since.

4.3: Remnants of the Past: Archaeological and Historical Remains of the Slate Industry on Random Island

After the collapse of Newfoundland's slate industry in the early 20th century many were left jobless as quarry sites were abandoned. Despite its short-lived rise and fall, the industry produced notable material remains that allow for the exploration of the physical and cultural landscape that the quarrymen occupied. Moreover, the ways in which the slate quarries affected individuals and communities can be readily seen and understood. This section provides an overview of the historic quarrying sites around Trinity Bay and their associated material culture remains, archaeological evidence of Welsh quarrying techniques, and an exploration of the ways in which the industry has left its mark on the local communities. The combination of history and archaeology contributes to a more holistic understanding of Random Island's past and its understudied slate industry.

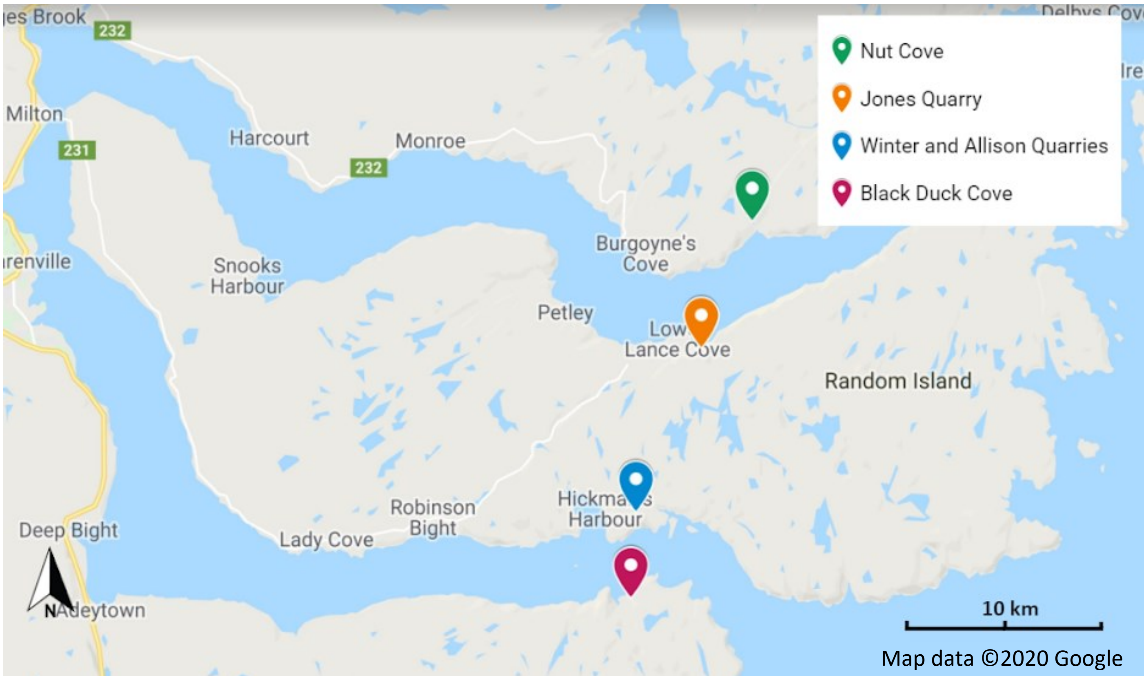

Figure 33: Map depicting the known historic quarries of the Random Island area. Map produced by Johanna Cole.

4.3.1: Nut Cove

After the closure of Nut Cove in 1907, the quarry was left to fall into ruin. Gerald Penney's 1987 assessment of the site noted that features such as the wharf, boilers, forge, etc. were no longer in existence. The living quarters of the quarrymen, however, still remained just north of the quarry itself (Penney 1987:1). These quarters include cookhouses, bunkhouses, cellars, offices and barracks thought at certain periods to have housed up to 100 men (Penney 1987:1-3). Presently, beyond Penney's assessment which simply states the existence of the site, no researchers have studied or completed an in-depth survey of these living quarters. Coordinates were not included in Penney's report. Although it appears the site was scavenged after the quarry's closure, the remains could provide evidence for the lifeways of these quarrymen (Penney 1987:3).

After its closure, there were two separate attempts to revive the quarrying industry. In the 1980s, the quarry was reopened under Newfoundland Slate Inc. and the Ontario-based Miller-McAsphalt Group, but this venture only operated until 1998 (Alam 2005:31). Sporadic quarrying activity has taken place since the closure, but little is known about the output of material in the last decade. A second revival of quarrying in the area was attempted by Hurley Slateworks in 2000, but also closed approximately ten years later (Alam 2005:31). Today, the Hurley quarry lays abandoned and falling into disrepair. Safety equipment, office documents, and slate slabs all lay in-situ, as though the workers left at the end of their shift and never returned.

4.3.2: Black Duck Cove, Allison and Winter Quarries

With the closure of Nut Cove, many employees sought jobs at the other three quarries in operation at the time. As stated previously, these quarries also closed in 1910 after only three years of operation (Evans and Dickson 2004:44). Although these quarries were smaller in scale than Nut Cove, they still would have left some form of evidence of the people who lived and worked there. Unfortunately, there is very little historic documentation pertaining to these quarry operations and minimal secondary literature exists. In addition, the three quarries are all only accessible by boat and were unable to be surveyed during this research. Metal detection by local hobbyists have uncovered evidence of an iron rail system at the site of the Allison quarry, as well as the presence of at least one working face (Norman Marsh, pers. comm., 18 May 2019). Beyond the findings of locals, little is known about the remains of the Black Duck, Allison and

Winter quarries. These sites would benefit greatly from further investigation in order to better understand the lives of the quarrymen who worked and potentially lived there.

4.3.3: Preliminary Surveys of Random Island Prospects

After an initial visit to Random Island in 2018, a preliminary survey was completed in the spring of 2019. This survey covered multiple features near Hickman's Harbour, believed to be part of the prospects worked by Charles Byrant in the 1860s and subsequently sold to Allison. The site featured an adit (Figure 34), a stacked stone structure and two quarried "cuts" into the hillside. The trip also included a visit to the defunct Hurley Slate Works and Newfoundland Slate Inc. on the north side of Smith Sound. These preliminary surveys were intended to assess what remained of the quarry operations in the area, if any, as well as seek protection for the Byrant/Allison property as a designated archaeological site.

Figure 34: The mouth of the adit with discarded material visible in the foreground. Photo by Johanna Cole.

The adit and its associated features are a 30 minute walk on an ATV trail east of Hickman's Harbour. The site displays evidence of worked, high quality, purple and green slate around the mouth of the adit. The first several meters of the adit measure seven feet high by six feet wide

(2.1 metres and 1.8 metres respectively). Further in, however, the height of the ceiling shortens and the tunnel begins to slope upward, as if it was being opened into a chamber, before abruptly ending at a wooden retaining wall approximately 60 metres from the opening. As discussed previously, the practice of underground “pillar and chamber” technique is common in Welsh quarrying (Gwyn 2015:60). Most interestingly, the quality of the slate deteriorates as one proceeds into the adit, becoming increasingly friable. This deterioration in quality may explain why the preliminary chamber was never completed and the adit was shored up and abandoned.

The floor of the adit features an intact wooden rail system, and a lack of iron or evidence of iron corrosion suggests the use of sledges rather than traditional mine carts on rails. This rudimentary transportation system roughly matches the 0.6m gauge tracks which were an industrial standard used in Welsh quarries and were also used along the Ffestiniog Railway (Gwyn 2015:133; see Figure 35). Metal detection by local inhabitants has led to the discovery of at least one horseshoe on the site, suggesting the use of horses or ponies for carting material (Norman Marsh, pers. comm., 18 May 2019). The walls of the adit are lined with circular and linear indentations from the use of pneumatic drills or, more likely, a *jympar* to extract slate, once again mimicking common Welsh quarrying techniques.

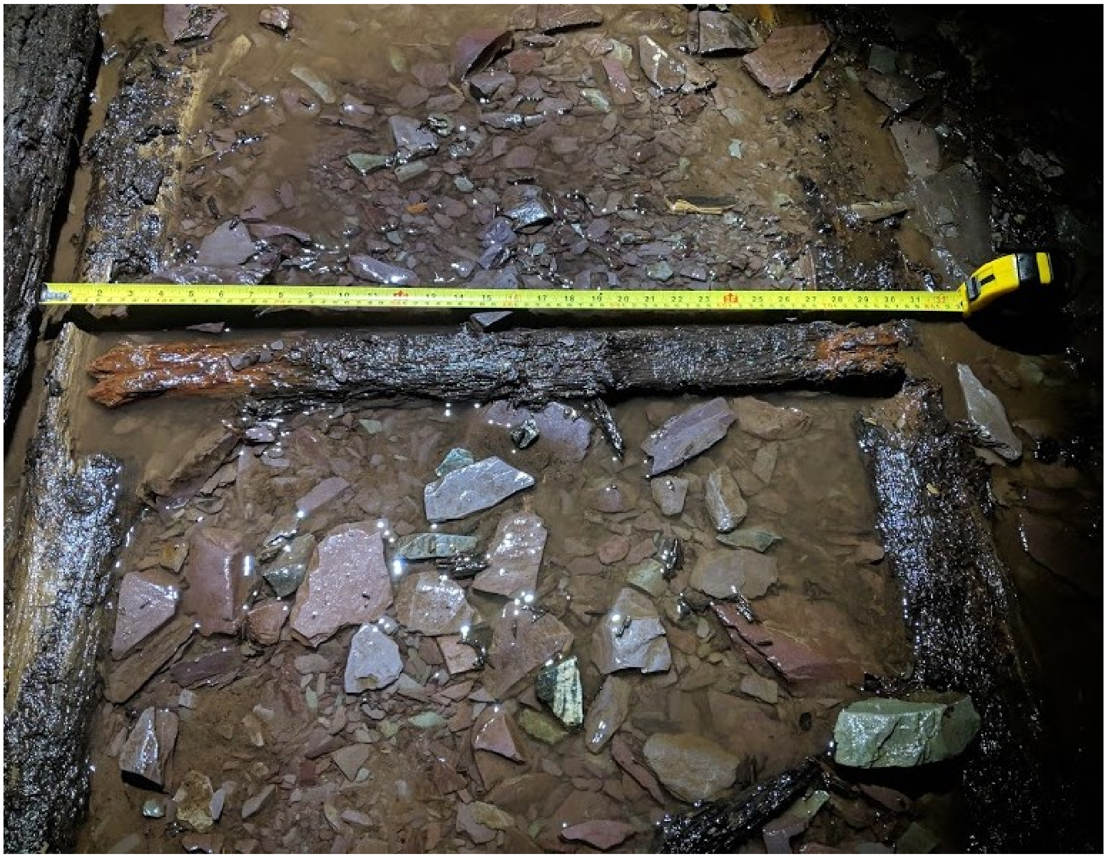

Figure 35: The remains of the old wooden rail system within the adit. Note the lack of iron staining, with the exception of where the sleeper was fastened to the rails, likely with iron nails/spikes.

Several hundred metres to the east of the adit are two cuts into the rock face and a stacked stone structure, all in association with one another. These cuts, now significantly overgrown with plant life, both measure approximately 10 metres in width and length. The stacked stone structure just several metres away is overgrown in a similar manner. This structure is reminiscent of the previously discussed Welsh *gwal*, or splitting shed, which was traditionally a three-sided structure in which blocks of slate were split and trimmed into roofing tiles. It features three thick walls, approximately a metre thick, of stacked slate stone, with an opening, potentially a doorway, along the wall nearest the quarry face (see Figures 36 and 37). The structure is completely open on the opposite side, with the walls beginning to collapse into rubble towards the open end. Any evidence of a roof or roofing material has been buried under rubble and a significant amount of overgrowth, but the area surrounding the structure was littered with slate trimming waste, some of which bore the tell-tale signs of tool use (see Figure 38). A similarly constructed trimming shed, with two large walls, a partially open third wall and a cantilevered roof, can be found at Foel Quarry in Nantconwy, Wales (Gywn 2015:104). Although further archaeological investigation is needed to fully determine the structure's construction and use, these preliminary findings suggest a strong similarity to the Welsh *gwal*.

Figure 36: Johanna Cole stands inside the stacked stone structure, with the tape pulled to a metre.

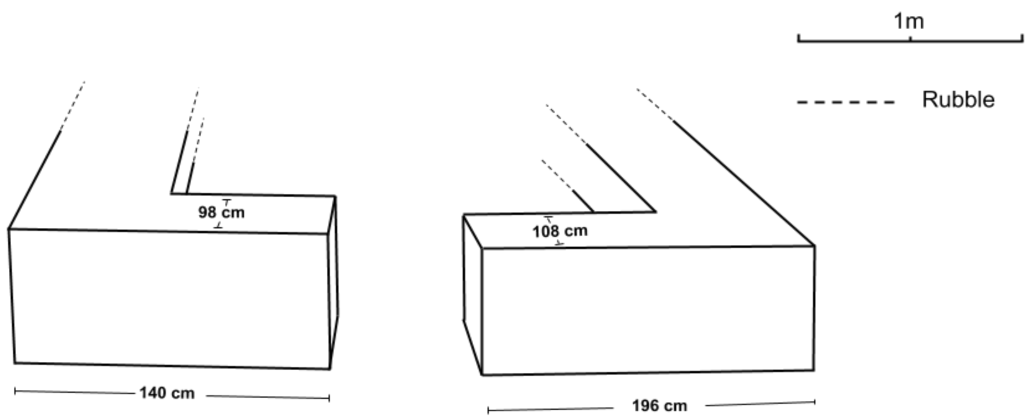

Figure 37: Diagram depicting the measurements and morphology of the stacked stone structure. Figure by Johanna Cole.

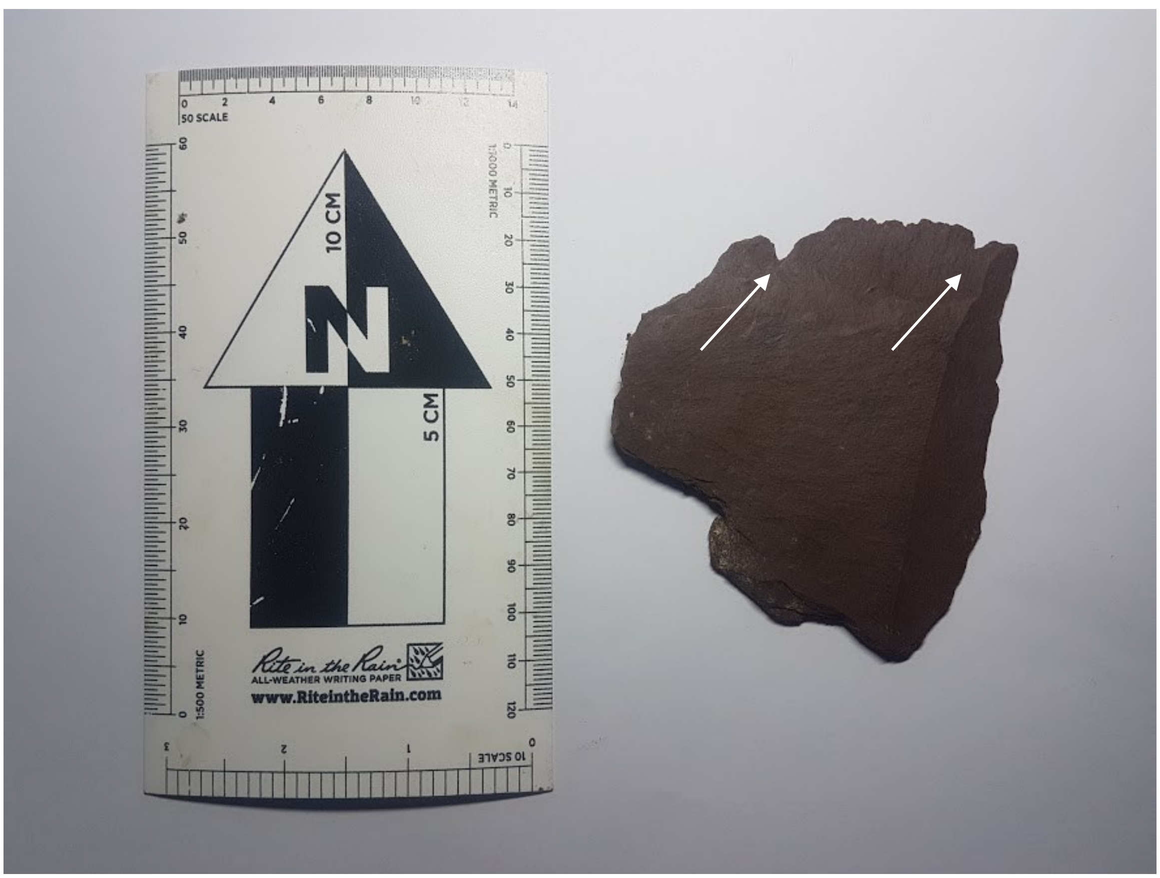

Figure 38: A piece of slate debris recovered from the interior of the stacked stone structure. The top edge has two large indentations which resemble those made by a slater's knife during trimming.

A 2012 prospecting report submitted to the Geological Survey incorporates a list of modern and historic quarrying activities on and around Random Island (Ryan 2012:4-7). It provides a description of a site called "Strong Tickle West", a prospecting site worked by Byrant in the 1860s that is described as a slate works with "three rooms up to 10 m square with an underlying adit approximately 60 m in length" (Ryan 2012:4). Although only two of the rooms mentioned in this document were located — based on the level of plant overgrowth and the matching description of the site — it is highly probable that these features are associated with Byrant's prospecting activities. While there is very little in the way of documentary evidence regarding Byrant's activities or the workmen he employed, the archaeological remains and the quarrying techniques employed at the site strongly suggest a Welsh presence.

After the survey just outside Hickman's Harbour, we continued to Nut Cove to assess the current quarrying activities. Both Newfoundland Slate Inc. and Hurley Slateworks are not actively quarrying, but access to the Newfoundland Slate Inc. site was prevented by ongoing industrial activity. Hurley Slate Works was completely abandoned and was a grim representation of how the slating industry has dissolved. It was here that the largest amount of quarrying activity occurred, not only during historic times (during the Currie and Carberry occupation) but also during the industry's revival in the early 2000s. The operation appears to have been significant, with a large galleried quarry site and so much slate waste that the tipping piles can be seen falling into the ocean from satellite images. The mill and administrative building have both now fallen into disrepair.

The construction of the road to access the Newfoundland Slate Inc. and Hurley Slateworks is what warranted Gerald Penney's 1987 report of the site. The original early

20th-century lodgings of Nut Cove quarry are reported to be just above the current location of Hurley Slate Works. However, due to snow, debris and a lack of coordinates the site was unfortunately not located on the 2019 trip to the area. These structures would benefit from a secondary survey in order to assess their current state; few examples of early slate quarryman's barracks exist in Canada, making the Nut Cove site one of historical importance.

4.3.4: The Heritage of the Slate Industry

Despite the numerous failed attempts to reinvigorate the slate industry, prospection of Random Island slate continues to this day. The Geological Survey of Newfoundland and Labrador declassifies prospecting reports several years after they have been completed, making it difficult to track the most recent developments in the area. However, it appears that mapping, sampling and drilling are still occurring, representing a continuance of the industry, however small. For the residents of the island, who are presumably minimally involved in these prospecting projects, the industry remains alive in different forms through historic material culture. Slate roofs still appear on historic homes on the island (see Figure 39). The Currie Premises is one of the island's buildings which retained its original slate roof, and the home remains a representation of the slate industry, its associated Welsh cultural presence and its impacts on the local communities.

The study of industrial sites and historically-industrialized communities is not only important as a means to highlight their historical and archaeological value, but is also integral to the study of the individuals who were affected by industry. The growth of the slate industry brought jobs and prosperity to Random Island and its closure impacted both individuals and communities. However, researching industrial activity involves more than understanding an industry as a financial means to an end; industry can be a shared heritage that shapes cultures and customs of individuals and communities alike (Cossons 2012:9). Slate quarrying would have played a role in where people lived and the connections they made with others. Migrants into the area, particularly Welsh migrants who came specifically for slate, brought individual customs and practices. While Welsh is no longer commonly spoken around Trinity Bay, the language's influence lives on in the last names of multiple Random Island families, such as the Curries, to this day (Penney 1987:4).

Figure 39: One of the many houses on Random Island that has retained its slate roof, incorporating both of the locally-sourced green-blue and purple materials into an intricate pattern. Photo by Johanna Cole.

4.4: Concluding Remarks

Much of the literature pertaining to Random Island and the surrounding area discusses the industry but *not* its industrial heritage. This crucial difference overlooks individuals, such as the infamous Owen J. Owen, in the history of these places. With the abrupt rise and fall of the slate industry, the cultural lifeways of communities and individuals were dramatically shifted, all within the span of mere decades. The socio-cultural impact of a relatively small-scale industry like slate may not be as easy to identify within smaller communities like those of Trinity Bay. By comparison, the cod fishery is broadly known to be intertwined with Newfoundland culture and there has been significant research into early fishermen and their livelihoods. The impact this industry has had on the province, both in its success and collapse, is writ large across the history and archaeology of Newfoundland. Although much smaller in scale and much less obvious, slate's impact on the people and landscape of Trinity Bay was no less profound. Fully investigating the archaeological remains of the slate quarries in Newfoundland is a project worthy of a thesis or dissertation unto itself; moreover, it is clear that the remote nature of these sites has helped to preserve the traces of not only past industrial activity but also a strong Welsh cultural presence. Both the Allison quarry and Byrant's prospects have been disturbed by local metal detectorists, and the status of the Nut Cove structures is unknown. Future work must endeavour to thoroughly document and protect these archaeological sites before they are lost.

It is no surprise that Welshmen left their homes to work the fledgling quarries of Newfoundland. The grim conditions of their employment in Wales coupled with the promise of good wages and suitable housing, especially in the face of a faltering market, was no doubt motivation enough to leave. Quarries managed by their countrymen, in which their cultural traditions could be continued and their skills highly valued, would have been highly attractive to striking workers from Penhryn and Dinorwic. Already suited to remote territory and rugged terrain, quarrymen and their families continued practicing both their craft and their culture just as they had in Wales. The documentary accounts of Welsh church services, the archaeological remains surveyed near Hickman's Harbour, the extent examples of slate roofing and the persistence of Welsh family names are all proof of their impact on the cultural, architectural and physical landscape of Trinity Bay. Much like Irish and English settlers who arrived before them, Welsh quarrymen simply sought to carve out a life better than the one they had left behind. The knowledge and skills they brought with them had a direct impact on the way quarries were managed and how slate was extracted and processed. In this way, the boom and bust of Trinity Bay's slate industry is directly connected to the success and failure of its Welsh counterpart, just as the two are linked by the same geological deposit of Cambrian slate.

Chapter 5

Revisiting the Slate Handicrafts of Ferryland

5.1: The History of Slate Handicrafts

While there is a distinct lack of both historic documentation and academic literature pertaining to the creation of slate handicrafts prior to the Victorian Era, archaeological records from both Ferryland and across Europe make it obvious that the creation of both functional and decorative slate objects pre-dates the industry's boom in the 19th century. Slate's properties as a stone make it incredibly versatile in the hands of a craftsman; not only can it be split into thin sheets, but it can be easily etched, carved or ground down into any number of shapes. An incised Neolithic slate disc uncovered in Orkney bears a striking resemblance in size and shape to the discs or "pot lids" found in multiple contexts across the Ferryland site (these discs are discussed in section 5.2.4), and this roughly 4,000 year old example appears to have been made using similar techniques and was also found in association with pottery (Jones and Diaz-Guardamino 2019:60-61). Excavations in modern-day Abergele, North Wales have unearthed smoothly ground slate spindle-whorls dating to the late Roman/Early Iron Age (see Figure

Figure 40: Roman/Early Iron Age ground slate spindle whorl (Amgueddfa Cymru/National Museum Wales).

40). The carving of slate has been a medium for recording information since at least the 8th century: the "Hostage Stone", which was excavated from early monastic contexts on the Scottish Island of Inchmarnock, is one such notable example, depicting a monk being enslaved or held hostage by three chainmail-clad figures (Lowe 2007:61-62). Slate was a commonly-used material for bakestones in medieval Wales, and the tradition of baking bread on slate continued into the late 18th century (Lindsay 1974:18). The tradition of using slate to bake breads and pasties was also common in the English county of Cornwall, where large slate circles were used as "pasty boards" throughout the medieval period and into modernity (Buswick and Buswick 2006:12). Small slate discs with beveled and chamfered edges have been recovered from 15th-century monastic contexts in North Wales, closely resembling the gaming pieces or counters found in 17th-century contexts in Ferryland (discussed in section 5.2.3, see Figure 41).

Figure 41: Post-medieval slate objects from Llangollen, Wales (Amgueddfa Cymru/National Museum Wales).

The creation of objects which married both function and decoration did not flourish until the industry's boom in the 19th century, although there is evidence to suggest such creative ventures were alive and well in Ferryland during the early 17th century (see section 5.2.2). Wood carving techniques were adopted by quarrymen who used chisels and a number of other tools to beautify their otherwise dour cottages (Buswick and Buswick 2006:13). Miniature bureaus, figured bookends, game boards and carved slate mantels and fireplace surrounds were just some of the objects they created, in addition to carving commemorative signs and sometimes even gravestones (Buswick and Buswick 2006:13-14; Gwyn 2015:40-43). Carvings ranged from fanciful depictions of ships to simple initials, circles or linear patterns (Buswick and Buswick 2006:14) The creation of decorative slate fans became a point of pride among quarrymen, demonstrating the skill with which they could work the stone. All split from the same block, the individual blades of these fans were often so thin that "a razorblade might be used to split the last sections" (Buswick and Buswick 2006:14). These fans are a common sight in both museums and homes across North Wales, and the tradition has been kept alive by both modern quarrymen from Penhryn and retired workers from Dinorwic (Carwyn Jones, pers. comm., 31 May 2018). Slate has been used for purely decorative projects in recent times, with ornate carvings of dragons, sculptures made from stacked slates and even more abstract ground-stone pieces being created in Wales from discarded quarry waste.

Little is known about the creation of slate folk art in colonial North America beyond the realm of gravestone carving. The assemblage of slate artifacts recovered from

Ferryland, discussed below, therefore offers some of the earliest North American examples of a centuries-old tradition.

5.2: The Slate Objects of Ferryland

5.2.1: Gravestone Fragments

Three slate fragments from two separate gravestones have been recovered in Ferryland from mid-17th-century contexts. The largest of these fragments was found in the colony's eastern defensive ditch, while the other two were excavated adjacent to the brewhouse and bakehouse (Carter et al. 1998:57-58; Gaulton 2006:88). Although they came from Kirke-era deposits, Lacy et al. (2017) believe that the stones were likely carved from local material in the late 1620s and broken shortly thereafter, perhaps during Kirke's destructive reorganization of the site. The style of lettering coupled with the lack of weathering — of note is the fact that the carver's shallow guidelines are still visible — supports this proposition (Lacy et al. 2017:7; see Figure 42). The stones are a perfect visual match to locally quarried stone, and further testing using pXRF strongly supports the notion that the gravestone fragments and roof tiles were all sourced from local outcrops, namely stone belonging to the Fermeuse and Renews Head Formations of the St. John's Group (Lacy et al. 2017:15).

Figure 42: Slate gravestone fragment from Area F, Ferryland. Drawing by Robyn Lacy.

While some research has been done on early colonial stone carvers in the United States, almost nothing is known about gravestone carvers during Newfoundland's early colonial years. Although slate was extracted from outcrops near Boston Harbour as early as the 1630s for personal use, the erection of gravestones did not become popular in the United States until the mid-to-late-17th century (Buswick and Buswick 2006:33; Lacy et al. 2017:2). Newfoundland's assemblage of early gravestones is particularly small, due in part to the fact that early markers were typically made from wood or rough field stone. Although the Ferryland examples showcase lettering which suggests a familiarity with both lettering styles and working with stone, Lacy et al. assert that "some of the curves of the letters suggest unfamiliarity with letter carving" in particular (2017:7). This is consistent with research by Judy and Ted Buswick, which states that early colonial carvers commonly "earned their livelihood at other jobs, supplementing incomes by carving upon request" (2006:34). Their list of occupations includes masons and roof slaters, both of which were named or requested by Edward Wynne in his letters to Calvert (Buswick and Buswick 2006:24; Wynne 1622b). The Ferryland fragments were therefore likely carved by a stonemason, quarryman or slater — certainly someone intimately familiar with the properties of slate, but perhaps not with carving letters — to commemorate those who perished during the winter of 1628/1629. While the Ferryland gravestone fragments are not particularly decorative or artistic and their purpose is decidedly morbid, they are an excellent example of early 17th-century slate carving in a North American context. Moreover, they represent one of the oldest, if not the oldest, examples of locally-sourced stone funerary monuments in British North America (Lacy et al. 2017:16).

5.2.2: Sundial Fragments

A number of slate fragments with incised, radiating lines have been excavated from the Ferryland site, spanning a number of areas and contexts. The regular intervals of these lines coupled with numerals around their edges provide undeniable proof that the slate fragments belonged to sundials used by the plantation's early inhabitants to track the movements of the sun. Some of these pieces were found in Area B, in the vicinity of the forge, in contexts pre-dating the 1640s (see Figure 43). Although iron-stained and fragmented, they still showcase crisply incised lines and circles. A number of other sundial fragments have been found in Area F (adjacent to the mansion house) and Area G (north of Area F), but unfortunately most of these are from disturbed contexts. Although utilitarian in function and simple in their design, they are all examples of beautiful craftsmanship, with one large fragment showcasing skillfully incised Roman

Figure 43: Fragments of a slate sundial excavated from Area B, Ferryland. Photo by Barry Gaulton.

Figure 44: Fragment of slate sundial from Area G, Ferryland. Note the incised numerals and symbol on the upper edge. Photo by Barry Gaulton.

numerals and a symbol, perhaps a cross (see Figure 44). As with the gravestones discussed above, the sundials suggest a practiced skill in carving slate. Although the fragments in Figure 44 were found in layers deposited around the beginning of the Kirke occupation, there is little historical or archaeological evidence to suggest that the Kirkes had slaters or quarrymen in their employ (Gaulton 2013:283). These objects were therefore likely created during the Calvert era, but may have suffered a similar fate to the gravestones: being broken and discarded during the reorganization of the site. The quality of the carvings coupled with their context suggests that at least some of these fragments may have made by the quarrymen, masons or slaters which Wynne mentions in his letters (1622b).

5.2.3: Recreational Objects

Documentary sources from the early colonial period often concentrate on matters of business rather than recreation, and as a result archaeology must be employed to fill in the gaps of everyday life. Recreation is one area in which the material culture of Ferryland can shed light on the day-to-day activities of the colony's inhabitants, including the "girles" and "boyes" which Wynne mentions in a letter to Calvert (1622b). A number of small, circular slate discs, roughly 4 or 5cm in diameter, have been found primarily in Area F in the vicinity of the mansion house (see Figure 45). The discs which have been found in undisturbed layers come primarily from early-to-mid-17th-century deposits, and some also feature decorated edges or incised lines. These objects have been classified as counters or gaming pieces, despite the absence of any game boards being found. This absence may be due to the fact that early colonists simply played upon already existing tables or surfaces, or perhaps because game boards were made of wood and have thus been lost to deterioration. While backgammon, or "Tables" as it was known in the 16th and 17th centuries, has been attested to in 13th-century manuscripts, the game "enjoyed a tremendous revival" in the early 17th century (Bell 1979:42). The uniformity of their size suggests the 9 pieces found across the site served a common purpose, supporting their classification of gaming pieces, perhaps used for Tables or other board games. While counters and dice made from bone, pottery and wood are common in early colonial contexts, stone gaming pieces are less well represented (Hume 2001:319). Moreover, a fragment of slate with incised compass lines, creating a pattern of overlapping circles of the same diameter, provides evidence for the manufacturing of these pieces.

Figure 45: A collection of slate gaming pieces excavated at Ferryland. Photo by Barry Gaulton.

There is also evidence that these same gaming pieces may have been repurposed into children's toys. A singular example comes from an early 17th-century deposit in Area F, with a slate disc measuring roughly 42mm in diameter with two gouged-out holes in its middle. Identical to the gaming pieces in size and form save for these holes and some incisions along its outer edge, the piece has been identified as a whizzer or whirligig which would have been fastened to a loop of string (see Figure 46). The simple toy operated by twisting the string via swinging in circular motions and then pulling the string taught, resulting in a buzzing or whizzing noise. Like gaming pieces, these toys were typically made from discarded pieces of pottery, metal or even coins; Ivor Noel Hume remarked that he had "not seen a seventeenth-century example", making the whizzer from Ferryland a remarkable find in its own right (2001:321). While the slate counters are evidence of adult leisure, the whizzer is proof that the colony's youngest inhabitants also found time to play after their daily chores.

Figure 46: Slate whizzer uncovered in Area F, Ferryland. Photo by Barry Gaulton.

5.2.4: Pot/Jar Lids

As stated previously, a number of slate discs with beveled and chamfered edges have been unearthed at Ferryland over the last two and a half decades of excavation. Larger than the gaming pieces but similar in their form, these discs range in size from 9cm to 15cm. They are present in events which span over a century, from the 17th and into the 18th century, as well as within a number of disturbed contexts. They are overwhelmingly found in Area F, in the vicinity of the mansion house, buttery/pantry and adjoining kitchen, but some examples also come from Area B (adjacent to the forge) and Area G (east of the mansion house). While their function is still speculative, stone discs of this form and size are typically classified as "pot lids" due to the fact that they are typically found in association with ceramics, and in the case of Ferryland this classification is not without merit (Jones and Diaz-Guardamino 2019:60-61). The discovery of an incised pot lid within an 18th-century layer, bearing the initials "EL" (see Figure 47), spurred discussions that perhaps there was more to these objects than their assumed utilitarian function. It was suggested by a Welsh colleague of mine that perhaps the initials were those of the object's craftsman, and that these potlids were also made as practice or "show pieces"; such displays of skill were common in 19th-century Welsh quarries, with men creating slate objects (such as the decorative fans discussed previously) and showing them off with pride (Paul Doutch, pers. comm., 6 May 2018). The logic followed that a considerable amount of skill must have

Figure 47: Incised slate pot lid excavated from Area B, Ferryland. Photo by Barry Gaulton.

been required to work an angular stone like slate into a perfect circle and that doing so would be an impressive feat.

It seems likely, however, that these discs were indeed used as lids for ceramic jars and pots, especially given their proximity to structures associated with food preparation and storage. The weight of the stone and its even surface would allow the lid to seal well to the rims of ceramic vessels, a factor which would have been of great importance in the case of fermentation and long-term storage of food. Although lids for ceramic cooking vessels and pots did exist, many were made from biodegradable materials and as a result lids are less prominent in colonial archaeological records. Ceramic lids would presumably be easily lost or broken, and slate lids could be made from material readily at hand, preventing the need to ship replacements from England. While it is certain that cheese and cream was most certainly being made during the Kirke occupation, less is known about dairying activities during the Calvert period (Gaulton 2006:116). Cattle are, however, mentioned several times by Wynne in his letters (1622b). Given the importance of cheese as a protein source in colonial diets, it is likely that if Wynne was keeping cattle that cheese, cream and butter were also being produced (Deetz 1977:77). Cleanliness and sanitation was of utmost importance in such endeavours, and slate could be easily cleaned like the glazed earthenware containers that were commonly used in colonial dairies (Deetz 1977:77). Although none of the potlids were found in contexts directly associated with the Kirke-era buttery or dairy, it is probable that they were put to use in such a capacity during both the Calvert and Kirke occupations. The durability and portability of these lids, coupled with their usefulness, means they were likely used, re-used and transported from building to building and from function to function over the span of many years. This could explain why they appear in such broad temporal and spatial contexts.

5.3: (Re)interpretations?

The function of many of the slate objects found at Ferryland is made obvious by their form, with the obvious exception being the slate "potlids". As discussed above, it seems likely that they were, indeed, used as lids for various storage and cooking vessels; if the Neolithic finds from Orkney are any indication, it would seem that the tie between slate and pottery has a 4,000-year old history. These objects were likely created by slaters, quarrymen or masons, perhaps in exchange for food or services from the kitchen staff of the colony. Rather than being the signature of a workman, the initials scratched onto the 18th-century disc likely belong to its owner, possibly a woman working in one of the many kitchens at Ferryland (Mared McAleavey, pers. comm., 4 October 2019). This practice is not unheard of: 17th century ceramics and glass frequently bear the initials of their owner, and prior to 1760 mugs in taverns "were incised with the name of the tavern keeper and the date" (Deetz 1977:113-114). These freehand inscriptions were later replaced with stamping. The theory that these discs were difficult to manufacture, or that they perhaps may have also been practice pieces, was thoroughly debunked during the North Wales research trip discussed in section 3.2.1.

The presence of skillfully worked slate in contexts which have a wide temporal range raises interesting questions: did the slaters, masons and quarrymen which Wynne brought to work at the plantation continue to live in Ferryland after Calvert's expulsion? Did they pass their skills and knowledge on to their descendants, or to other members of the colony? Or is it simply likely that the enduring nature of stone allowed for objects to be used, re-used, and transported across the site for decades after they were created? All of these theories are certainly plausible, but without further documentary evidence it is nearly impossible to determine the historical truth.

What is evident, however, is that the culture of creating from slate, which flourished in 19^{th}-century Wales, can be found in 17^{th}-century Ferryland. This, of course, is not surprising: similar circumstances of geographical isolation, necessity, familiarity with the stone and an abundance of material led to the use of slate for both utilitarian and decorative objects in both contexts. Not only did slate cover their homes, but it became part of everyday life in both Ferryland and Wales through the creation, use, reuse and destruction of slate objects.

Chapter 6

Discussion and Conclusion

This research project endeavoured to build upon the work of Gaulton (1997), filling in the gaps of knowledge left by the lack of documentary evidence. The fieldwork and methods discussed in previous chapters were designed to meet several goals: 1) to understand the motivation behind using slate tiles over other conventional roofing material; 2) to understand the spatial distribution of tile manufacturing activity at the plantation site; 3) expand upon previous searches for Wynne's 17th-century quarry; and 4) to better understand the social aspects of the industry, including long-term cultural impact. While there is reason to believe that some of the original settlers hailed from Wales, the overwhelming focus on Welsh quarrying and processing methods falls squarely on the shoulders of Welsh Captain Edward Wynne, who was responsible for the "fitting" of a quarry and the construction of the early slate-roofed buildings (1622b).

6.1: Statistical Analysis

Post-excavation analysis of slate chip samples, the results of which can be found in Chapter 3, served to compare archaeological samples from Ferryland against modern experimental samples collected during fieldwork in North Wales. Given that $p < 0.05$ in all cases, the perceived differences between the means of the Ferryland samples and the Welsh samples are indeed significant. On average, the pieces in the Ferryland samples are larger than those collected during the trimming stage in Wales, despite a lack of evidence for multiple discrete stages (i.e. multiple means) in the data. There are several possible explanations for the larger size of the Ferryland sample pieces, the first of which is the coarser and more varied nature of the material used during the construction of the colony. The use of rough slate and shale, especially with inclusions like fossils, quartz and pyrite, would result in larger pieces of waste being discarded during manufacturing. This is especially true when compared to the high-quality, fine-grained and uniform slate slabs used for demonstration purposes at the Llanberis museum.

The difference in size, however, may also be due to differences in manufacturing. The Llanberis slate, as stated in Chapter 3, was prepared into a 30cm x 30cm x 10cm block prior to splitting, meaning that very little trimming was required to work the sheets down into a tile. The Ferryland operation, on the other hand, would have blocks of varying sizes as sawing quarried stone down to tidy, uniform blocks was likely not possible or efficient. Rather, the slaters would have made do with whatever they were given, and the need to trim down large, uneven sheets likely produced a great deal of waste and, in conjunction with the poor quality of the stone, larger pieces.

6.2: Answering Research Questions

6.2.1: Why was slate favoured as a roofing material at Ferryland over other common materials?

While slate tiles had been used for centuries in the Old World, there is very little evidence for its use in early North American colonial settings. The exploitation of local material for this purpose was even more rare, as even the Jamestown colony used slates which were likely imported from Wales. To the author's knowledge, the Ferryland site is the only early North American colony to quarry and process stone for the purpose of roofing structures. Setting up the small-scale industry required to supply the colony with necessary materials was no small task. The fact that Wynne asked for “tile for a beginning whilest the slate-quarry is in fitting” is testament to this, as it suggests that “fitting” the quarry would take long enough to make requesting (and waiting) for tiles worth it (1622b). Given the high waste to product ratio observed at Welsh quarries, where slate was considered to be of excellent quality, a great deal of raw material would have been required to roof all of the colony’s large early buildings. The mammoth task of procuring and processing so much slate becomes even more impressive when one considers how few men Wynne had at his disposal. All this begs the question: why did Wynne decide to use slate in the first place?

A good clue comes from Wynne directly, in his letter dated August 17th, 1622:

> “I shall humbly also desire you to remember my last yeeres suit, that our delicate harbours and woods may not be altogether destroyed. For there have been rinded this yeere not so few as 50,000 trees, and they heave out ballast into the harbours, though I look on.”

The harsh coastal environment of Ferryland is not well-suited to dense woodland, and colonists likely had to travel several kilometres inland to find suitable lumber. The overwhelming amount of wood required for construction as well as the operation of multiple ovens, a limekiln, the forge and the saltwork would have resulted in the depletion of such a finite resource. This does not take into account the wood required to heat homes during the long, cold winters. The above passage suggests that Wynne was acutely aware of this problem, especially after the effort required to procure the lumber required for the palisade walls. While the earliest structures were roofed with wood ("duck board") and thatch, the flammable nature of these materials and his awareness of available resources may have led him to seek alternative materials.

6.2.2: Was there a centralised area on the site for working slate, or was the material processed as-needed in close proximity to buildings which were under construction?

The archaeological investigations of this research project have confirmed previously proposed theories that slate was worked into tile next to buildings under construction, rather than in a singular processing area. The deposit of slate chips excavated behind the mansion house by Gaulton and his team (Gaulton and Hawkins 2014) as well as the similar deposits discovered in the vicinity of Feature 217 confirm this. Moreover, the occurrence of two deposits at both the north and south corners of the gable wall of Feature 217 suggests one of two things: either a singular slater made slates for one pitch of the roof before moving to the other, or, as Wynne's request for "a slator or two" suggests, two slaters each made tile at either end of the building. The location of the deposits at the western end of the building also suggests that the workmen may have begun roofing at the western edge, working their way east. This method, as opposed to working in full courses from the eaves to the peak, prevents possible damage to the tiles as workmen crawl over the roof.

The size and shape of the chips in the deposit point to the latter stages of tile manufacturing, namely trimming/dressing and finishing, rather than the full process described in Chapter 2. The spread of the chips and the quantity of manufacturing waste supports the theory that these deposits represent more than merely trimming the tiles to fit; the larger size of the chips in comparison to the experimental sample collected in Wales also supports this. Moreover, the excavations adjacent to the mansion house and Feature 217 did not produce any debitage that could be interpreted as splitting debris, but this is not surprising: good quality slate produces nothing more than dust when split into sheets. Even if we assume that the Ferryland material was full of inclusions, like the slate collected from Rhiwbach Quarry, the potential waste from splitting may have been used in reclaiming land along the northern (inner harbour) side of the plantation or as general purpose fill during construction.

6.2.3: Are there material signs of 17th-century activity at previously proposed quarry sites? Are there alternative locations for Wynne's quarry? If so, do these material traces point to a large or small scale quarry operation?

The surveying undertaken during the course of this research has shown that not only are the previously proposed quarry sites unlikely to be the quarry which Wynne wrote about in his letter, but they are also not readily conducive to archaeological investigations. While the sites proposed by Gaulton (1997) were close to the colony and had good-quality outcrops of the same material, these sites were small in scale and the terracing appeared natural rather than man-made. If material was gathered at these locations in the 17th century, it is likely that they were sites where smaller amounts of material were scavenged rather than being a quarry that Wynne describes as needing time for "fitting" (Wynne 1622b). These locations have also experienced a great deal of coastal erosion, and their small beaches were comprised of large cobble overlaying fine beach sand. If any intact 17th-century deposits were to be found, the effort required to find them was beyond what was possible for this project.

The coastal surveys have, however, resulted in the location of another possible quarry site north of the colony. The shape of the cut, the presence of visible terraces, the quality of the material and the near-vertical plane of cleavage make the location behind the Baltimore School in Ferryland an enticing one. As with other spots along the Irish Loop coast, this site has also experienced a great deal of coastal erosion and any signs of potential 17th-century features have long since been washed out to sea. Our test pit at this location mirrored what we found at other locations along the same coastline, with large cobbles, a layer of sandy beach deposit and a high water table making archaeological excavation exceedingly difficult and beyond the limitations of this project. Further investigations are necessary in order to find material traces, if any remain, of 17th-century activity at the site. The size of this probable quarry is substantial, and would have required significant preparation in addition to a number of workers to extract and move the quarried stone.

6.2.4: Are there possible alternative interpretations of the other slate artifacts found at Ferryland?

As discussed in Chapter 3, the Welsh tradition of creating both utilitarian and decorative items from slate was alive and well in 17th-century Newfoundland. Grave markers, gaming pieces, children's toys, sundials and "pot lids" were all crafted from locally-sourced materials. While the function of the majority of these slate objects was obvious, the "pot lids" were slightly more enigmatic; their mystique was only heightened by the fact that they appeared in contexts across the site and their occurrences spanned over a century. The theory that these were practice pieces, spurred by the discovery of a slate disc incised with the initials “EL”, rested largely upon the premise that cutting an angular stone like slate into a perfect circle must have been difficult. The demonstrations carried out by Welsh quarrymen, discussed in Chapter 3, thoroughly debunked this premise. In addition, the co-occurrence of stone discs in association with pottery dates back to the Neolithic period, suggesting that these “pot lids” were, indeed, lids for pots. The durable and portable nature of these objects likely resulted in their transportation, use and re-use in a number of different buildings over many decades, partially explaining the spatial and temporal breadth of their deposition. This fact may also help to explain the incised initials: being easily “borrowed” but invaluable for sealing containers for food storage or fermentation, the lid’s owner may have sought to mark their property

6.3: Conclusion

As is common with many instances of colonial settlement, the 17th-century slate industry at Ferryland exhibits a blending of the old and the new. While some industrial practices were retained, there were indeed deviations. The trimming of tiles beside buildings under construction, for example, certainly differs from Old World practices. On the other hand, coastal quarrying and the transportation of material by boat was nothing new. The cliff-side quarries of the Pembrokeshire coast described in historical documents and the recovery of early slate barges in Wales suggest that these were common practices even as early as the 16th century. The archaeology at Ferryland confirms the use of tools which were attested to in Holme's *Academy of Armory* (1688) and are still in use by modern quarrymen today, namely the roofer's hammer and the slater's knife.

Any deviations seen within the archaeological record of Ferryland are likely a byproduct of simple necessity, born out of a shortage of nearby timber stands and the fact that the stone was needed for much more than just roofing tile. The slate and shale pried from the cliffs of the Avalon Peninsula was also destined to become flooring slabs, building stones and even fill for land reclamation. The seawall, privy and a number of other structures were built from slate stone which was worked into blocks and laid in mortared courses (Gaulton 1997:131). While the roof tiles would have been split by the slater(s), the task of preparing building stone likely belonged to the six masons which Wynne requested (1622b). As discussed in Chapter 5, slate was also used to manufacture a number of other unassuming but useful handicrafts. Although mundane and utilitarian in nature, the 17th-century slate objects found at Ferryland are an early expression of a culture which is readily familiar to any modern-day Welshman.

The choice of materials used by craftsmen is directly influenced by human interactions with the land and our understanding of it. As Ingold points out, the tasks which skilled workers perform in relation to the landscape are by nature social (and therefore cultural) practices (1993:158; Rajala and Mills 2017:10). In this way, the construction of the Ferryland colony and its associated archaeological record can be conceptualized as a socially-constructed "slate-scape": the humble practice of quarrying slate became inextricably linked with every aspect of daily life in 17th-century Ferryland, from major events like constructing houses to the less notable action of playing board games (and even the all-important task of going to the toilet!). Moreover, this 17th-century "slate-scape" is decidedly Welsh in its influence, due in large part to the life and experiences of Captain Edward Wynne. Familiar with both the rugged slate-laden mountains of Snowdon and the sea-side quarries of Pembrokeshire, it was likely second-nature to harvest material from the cliffs of the Avalon when faced with a lumber shortage and a need for materials which could withstand Newfoundland's famously harsh weather.

Unbeknownst to them, the 19th-century Welsh quarrymen of Smith Sound and the Bay of Islands continued to shape the "slate-scape" of Newfoundland. Their Old World relationship with the stone once again influenced New World industrial practices, altering the cultural landscape of Random Island and tying the stone to almost every aspect of daily life. Although these quarries are known to many, the richness of this cultural landscape was an unexpected discovery during the course of this research. Unlike the industry of the 17th century, the 19th-century quarries were well-documented and the cultural ties to Wales are made obvious in numerous newspaper articles and archival documents. Where documentary evidence is scant, such as in the case of Byrant's early prospects, traces of Welsh influence can once again be found through archaeological means. In particular, Random Island and the surrounding area is brimming with 19th-century industrial archaeology which requires both further research and protection.

As this thesis has endeavoured to demonstrate, the Welsh practice of quarrying slate and transforming it for a variety of uses, from roofing tiles to gaming pieces, has had a profound impact on Newfoundland's history. While the island bears the physical scars of both 17th- and 19th-century slate quarries, the enduring presence of slate roofs, Welsh surnames and an archaeological record saturated with slate is a less obvious testament to its importance. Newfoundland owes much to both Captain Edward Wynne and the Welsh propensity for working with slate: it is likely that without Wynne's quarry, the Ferryland colony would not have flourished as it did. It seems only fitting, then, that the windswept island upon which 17^{th}-century colonists built their homes is affectionately known as "The Rock"; while the fishery was undoubtedly the reason for Newfoundland's initial settlement, so much of its early history and industry was, quite literally, set in stone.

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APPENDIX A
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Price, Carwyn, 2018.
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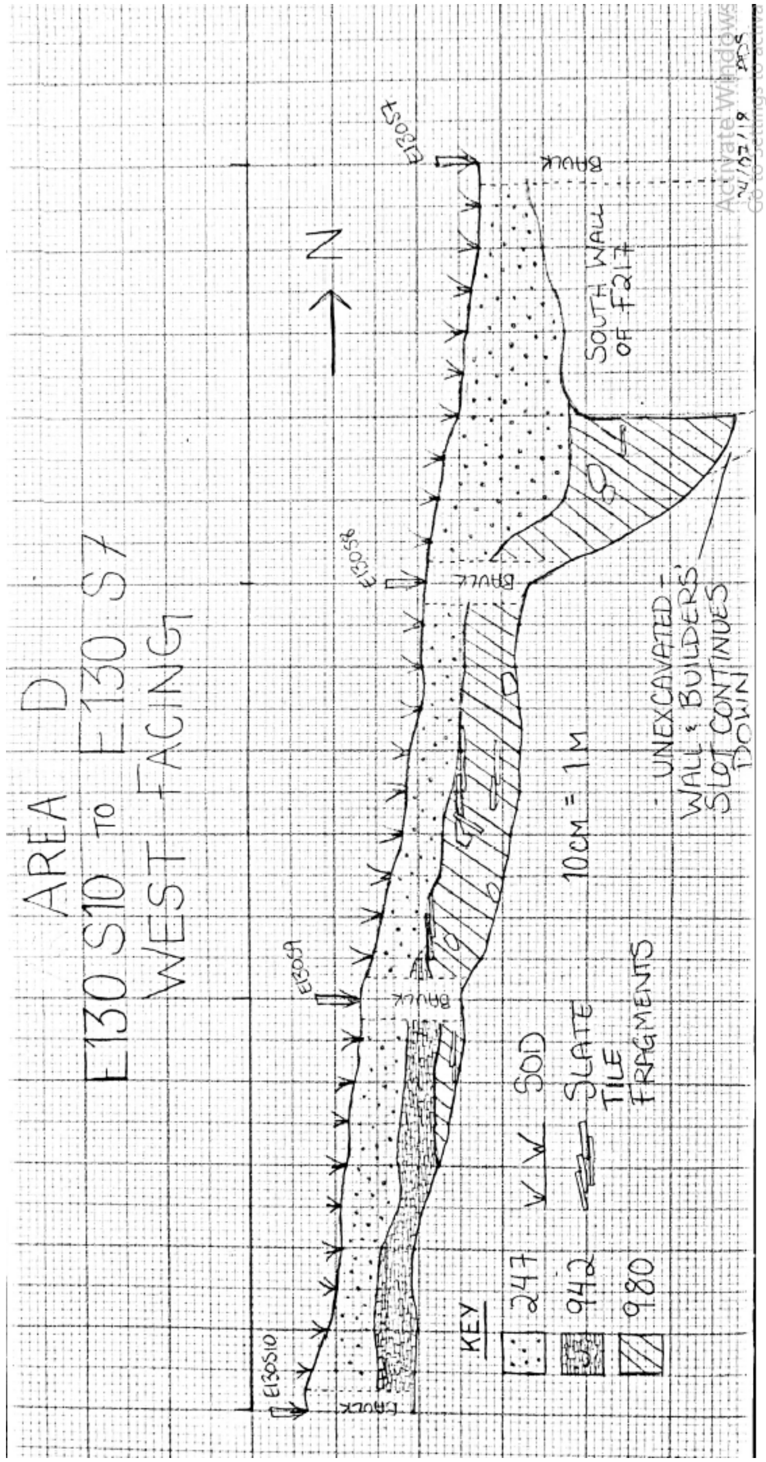
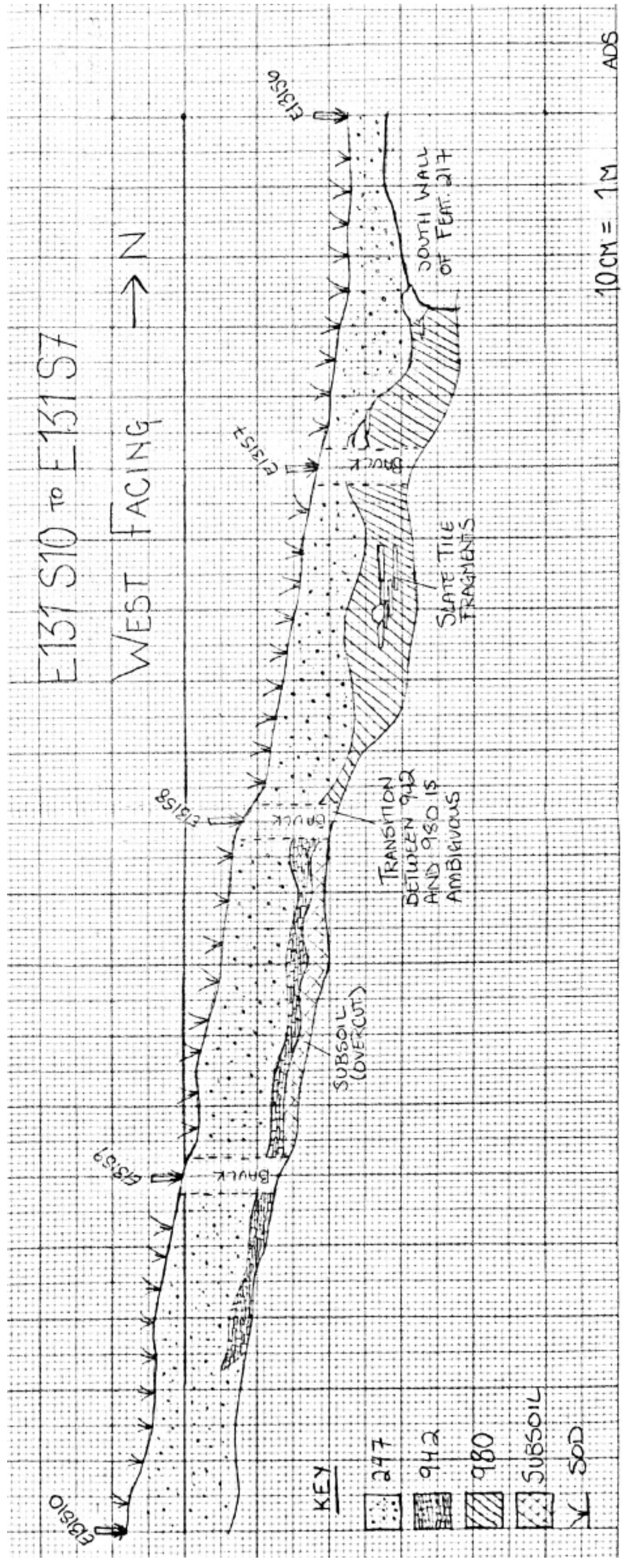
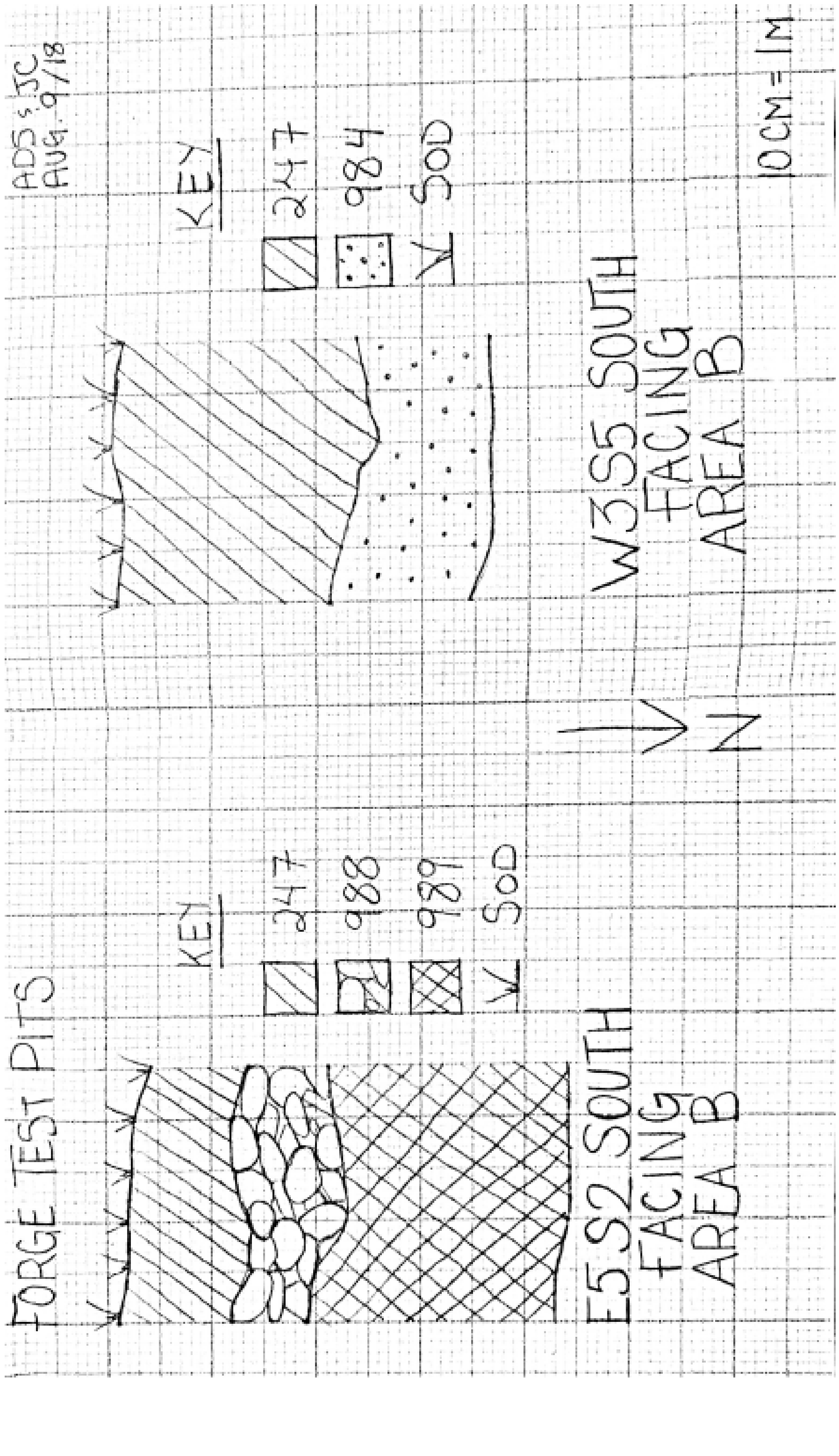
APPENDIX B
Section Drawings




E131 S10 to E131 S7
West Facing → N
BAULK
SUBSOIL (OVERCUT)
TRANSITION BETWEEN 942 AND 980 IS AMBIGUOUS
SLATE TILE FRAGMENTS
SOUTH WALL OF FEAT. 217
10CM = 1M
ADS
KEY
277
942
980
SUBSOIL
SOD


FORGE TEST PITS
E5 S2 SOUTH
FACING
AREA B
KEY
247
988
989
SOD
N
W3 S5 SOUTH
FACING
AREA B
KEY
247
984
SOD
ADS & JC
AUG. 9/18
10CM = 1M

APPENDIX C
Slate Chip Data

AREA D – E130NO

Weight (g)	Length (mm)	Width (mm)	Surface Area (mm)
94	120.33	89.57	10777.96
77	102.86	52.45	5395.01
157	108.52	102.15	11085.32
29	96.43	44.7	4310.42
52	99.95	60.82	6078.96
114	144.6	62.87	9091.00
162	160.5	85.92	13790.16
98	123.04	73.58	9053.28
89	113.68	75.85	8622.63
62	96.85	53.45	5176.63
29	61.65	45.33	2794.59
26	59.28	51.95	3079.60
119	104.91	100.05	10496.25
31	73.05	24.99	1825.52
33	63.98	50.68	3242.51
7	50.67	24.28	1230.27
12	56.6	34.93	1977.04
9	43.44	22.37	971.75
20	61.05	34.29	2093.40
20	52.02	44.03	2290.44
10	54.27	26.57	1441.95
144	191.3	57.4	10980.62
61	105.16	54.46	5727.01
3	23.93	21.08	504.44
2	30.2	13	392.60
1	28.41	8.02	227.85
23	55.74	40.61	2263.60
31	88.33	46.87	4140.03
53	57.35	53.68	3078.55
83	119.63	56.62	6773.45
9	43.69	29.93	1307.64
20	58.6	54.47	3191.94
15	64.29	38.26	2459.74
3	45.12	22.06	995.35
2	22.61	12.44	281.27
9	57.65	29.02	1673.00
15	60.04	28.05	1684.12
15	50.59	35.56	1798.98
4	25.39	23.01	584.22
2	30.51	18.16	554.06
13	39.64	34.94	1385.02
29	65.34	49.36	3225.18
75	149.08	64.43	9605.22
23	93.46	34.46	3220.63
36	73.43	49.93	3666.36
3	25.39	23.71	602.00
6	34.39	27.04	929.91
15	56.14	28.68	1610.10
22	57.63	46.88	2701.69
12	35.89	39.37	1412.99
17	59.55	30.99	1845.45
196	148.38	81.99	12165.68
29	88.01	33.28	2928.97
80	109.17	53.89	5883.17
12	53.92	32.24	1738.38
13	48.87	32.73	1599.52
41	111.12	39.55	4394.80
5	33.04	21.58	713.00
28	71.2	60.21	4286.95
9	49.44	20.03	990.28
15	42.68	37.04	1580.87
4	32.36	17.05	551.74
1	25.93	14.73	381.95
4	34.94	19.42	678.53
62	69.97	59.46	4160.42
1	20.95	10.44	218.72
2	28.42	19.18	545.10
7	30.41	27.93	849.35
4	38.88	14.93	580.48
3	30.97	21.73	672.98
2	22.65	14.57	330.01
2	18.79	18.87	354.57
0	13.97	6.92	96.67
0	6.72	5.58	37.50
0	23.75	11.66	276.93
0	22.93	8.07	185.05
0	17.64	14.02	247.31
0	14.96	7.43	111.15
0	19.22	9.44	181.44
0	18.09	8.69	157.20
0	18.89	9.77	184.56
0	18.6	11.17	207.76
3	37.42	20.58	770.10
2	45.01	17.45	785.42
12	48.87	28.1	1373.25
7	44.93	22.07	991.61
3	27.31	23.31	636.60
0	28.45	12.32	350.50
0	19.02	14.59	277.50
21	64.59	36.41	2351.72
10	53.17	25.28	1344.14
23	72.08	52.85	3809.43
32	81.89	46.51	3808.70
18	38.32	37.27	1428.19

39	86.45	42.17	3645.60
15	46.43	37.66	1748.55
10	52.47	36.79	1930.37
22	61.84	31.77	1964.66
15	52.97	33.31	1764.43
12	47.51	36.57	1737.44
29	68.4	39.17	2679.23
0	10.8	6.32	68.26
9	40.24	30.97	1246.23
6	43.32	20.73	898.02
8	53.27	20.85	1110.68
0	13.59	15.89	215.95
9	38.79	23.58	914.67
7	33.85	25.06	848.28
20	87.04	28.44	2475.42
11	54.81	30.06	1647.59
5	36.09	23.6	851.72
4	33.83	18.36	621.12
4	36.32	39.4	1431.01
44	104.71	49.22	5153.83
7	60.44	19.78	1195.50
0	17.15	10.53	180.59
0	8.32	6.28	52.25
1	24.48	11.58	283.48
3	24.45	24.07	588.51
6	55.85	27.9	1558.22
7	41.88	23.62	989.21
0	11.17	8.39	93.72
1	27.45	15.72	431.51
0	14.87	7.53	111.97
9	38.84	31.22	1212.58
3	29.48	20.19	595.20
0	20.02	12.47	249.65
4	39.77	12.15	483.21
2	24.48	12.06	295.23
2	31.7	9.5	301.15
3	31.97	18.88	603.59
2	22.3	15.9	354.57
1	26.28	15.84	416.28
0	13.84	12.69	175.63
2	19.34	13.67	264.38
0	29.8	10.59	315.58
0	11.9	11.34	134.95
1	18.68	16.66	311.21
0	16.56	12.83	212.46
0	21.12	11.2	236.54
0	16.37	8	130.96
0	19.58	8.42	164.86
0	12.42	11.17	138.73
0	15.8	8.66	136.83
0	12.16	8.78	106.76
0	11.71	10.63	124.48
0	11.24	9.69	108.92
0	11.74	7.83	91.92
0	9.31	6.66	62.00
0	7.45	6.55	48.80
0	15.67	5.07	79.45

0	7.8	4.31	33.62
0	10.61	4.04	42.86
131	142.56	68.61	9781.04
68	107.07	62.9	6734.70
85	114.21	62.54	7142.69
53	107.13	41.38	4433.04
13	64.05	27.29	1747.92
35	68.1	59.41	4045.82
41	116.13	45.58	5293.21
11	50.08	22.2	1111.78
10	45.41	24.19	1098.47
13	30.51	37.17	1134.06
0	17.24	13.06	225.15
0	22.37	18.51	414.07
9	46.5	26.81	1246.67
5	37.45	24.33	911.16
6	61.32	18.4	1128.29
3	25.22	21.2	534.66
6	37.23	30.91	1150.78
8	58.1	25.6	1487.36
11	28.91	24.31	702.80
2	21	16.41	344.61
0	14.04	11.29	158.51
2	31.29	12.66	396.13
3	34.45	14.11	486.09
0	20.94	15.04	314.94
0	16.1	11.97	192.72
11	42.98	34.37	1477.22
11	49.77	32.91	1637.93
2	20.93	18.46	386.37
3	28.33	19.75	559.52
5	31.68	17.24	546.16
4	20.88	17.56	366.65
4	29.94	20.33	608.68
2	20.85	17.72	369.46
2	38.25	12.4	474.30
2	23.83	16.06	382.71
2	18.52	15.88	294.10
0	17.94	10.05	180.30
1	18.56	16.01	297.15
0	17.9	11.02	197.26
0	20.58	11.44	235.44
0	12.52	7.6	95.15
0	15.8	9.1	143.78
0	12.15	6.74	81.89
0	9.7	7.76	75.27
23	81.26	34.77	2825.41
8	35.39	32.36	1145.22
7	40.09	27.47	1101.27
5	31.22	20.66	645.01
4	25.52	21.12	538.98
5	53.47	15.84	846.96
0	18.19	13.69	249.02
3	29.42	22.92	674.31
4	37.76	19.08	720.46
3	39.34	16.92	665.63
3	28.2	16.45	463.89

2	36.7	12.07	442.97
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2	32.67	17.36	567.15
4	35.7	22.6	806.82
0	13.54	11.14	150.84
0	14.46	8.8	127.25
0	14.47	12.91	186.81
0	13.23	9.42	124.63
0	22.04	9.83	216.65
7	45.48	38.77	1763.26
23	53.49	35.47	1897.29
17	61.72	22.32	1377.59
14	42.79	31.47	1346.60
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4	28.28	17.62	498.29
4	42.23	18.1	764.36
0	19.96	15.86	316.57
0	18.41	14.58	268.42
5	44.04	14.52	639.46
4	36.92	24.36	899.37
5	34.72	24.85	862.79
5	30.04	21.01	631.14
2	28.34	16.96	480.65
2	30.77	15.29	470.47
2	21.13	16.1	340.19
1	25.88	13.73	355.33
0	21.29	14.26	303.60
1	23.85	8.43	201.06
0	16.98	13.49	229.06
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0	23.02	9.23	212.47
0	16.73	11.98	200.43
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0	14.98	11.82	177.06
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1	18.39	11.1	204.13
0	19.68	10.7	210.58
0	13.2	10.73	141.64
0	23.5	6.61	155.34
0	15.21	7.97	121.22
0	14	8.07	112.98
0	11.17	6.9	77.07
0	10.62	9.24	98.13
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4	34.53	24.38	841.84
2	28.96	18.64	539.81
5	49.78	16.21	806.93
7	39.68	22.41	889.23
3	40.61	13.85	562.45
0	22.38	20.84	466.40
4	37.11	17.54	650.91

2	28.99	12.9	373.97
3	34.96	16.43	574.39
0	17.19	15.67	269.37
0	23.03	11.49	264.61
0	18.76	12.08	226.62
0	20.34	7.32	148.89
11	65.81	9.08	597.55
0	16.79	10.44	175.29
5	34.2	26.56	908.35
17	46.25	32.12	1485.55
8	48.51	25.99	1260.77
20	63.88	34.3	2191.08
4	34.63	26.22	908.00
5	32.58	26.23	854.57
7	44.52	28.1	1251.01
5	42.39	18.87	799.90
8	37.07	18.18	673.93
6	32.97	26.73	881.29
1	18.72	13.84	259.08
0	28.65	15.23	436.34
3	26.14	16.83	439.94
0	20.28	10.62	215.37
0	21.87	10.63	232.48
0	18.33	10.85	198.88
0	9.07	5.59	50.70
51	85.06	52.77	4488.62
6	40.74	17.64	718.65
0	17.05	8	136.40
0	19.87	15.03	298.65
7	54.41	25.23	1372.76
17	59.25	33.58	1989.62
4	29.86	17.39	519.27
3	35.11	18.21	639.35
2	34.41	15.7	540.24
1	24.62	13.61	335.08
2	28.7	16.31	468.10
0	22.23	17.22	382.80
0	19.4	9.19	178.29
0	16.65	6.98	116.22
10	49.97	24.19	1208.77
4	30.34	25.56	775.49
4	50.69	20.19	1023.43
5	44.89	23.92	1073.77
7	46	21.8	1002.80
7	36.51	29.9	1091.65
4	42.04	27.94	1174.60
4	33.48	22.62	757.32
4	35.76	20.62	737.37
2	23.59	18.73	441.84
2	36.03	15.24	549.10
4	43.48	24.5	1065.26
0	35.93	9.38	337.02
0	20.57	13.19	271.32
2	16.44	14.23	233.94
0	17.58	10.13	178.09
0	19.63	8.65	169.80
0	10.53	10.19	107.30

0	13.69	9.39	128.55
64	67.88	48.3	3278.60
5	39.75	23.44	931.74
6	33.52	24.32	815.21
8	38.41	20.72	795.86
7	35.68	22.01	785.32
3	37.53	21.12	792.63
1	20.72	17.86	370.06
1	17.26	16.37	282.55
1	21.43	11.66	249.87
3	25.76	19.21	494.85
2	28.48	13.35	380.21
0	15.34	10.83	166.13
0	25.84	10.29	265.89
0	14.71	12.92	190.05
0	11.6	8.11	94.08
0	19.32	5.88	113.60
5	46.13	18.89	871.40
5	28.58	16.72	477.86
6	37.32	23.87	890.83
6	41.59	15.59	648.39
4	34.09	22.4	763.62
4	34.16	18.7	638.79
4	37.54	21.07	790.97
4	28.87	22.6	652.46
3	32.87	17.84	586.40
5	30.95	27.39	847.72
4	47.41	23.47	1112.71
3	24.78	21.06	521.87
3	34.63	25.89	896.57
2	36.3	19.97	724.91
0	20.73	8.64	179.11
2	41.53	8.12	337.22
0	12.74	11.57	147.40
0	16.17	7.67	124.02
0	18.68	13.4	250.31
0	10.63	5.53	58.78
4	30.25	27.88	843.37
9	46.65	35.78	1669.14
6	41.53	28.71	1192.33
4	31.04	17.3	536.99
4	47.6	18.53	882.03
3	21.48	19.72	423.59
3	25.69	17.06	438.27
2	31.92	16.6	529.87
0	26.47	9	238.23
0	23.45	18.75	439.69
0	28.46	9.36	266.39
18	71.08	33.39	2373.36
29	57.47	42.77	2457.99
4	36.8	23.86	878.05
18	57.91	42.88	2483.18
15	86.88	25.72	2234.55
12	71.52	40.36	2886.55
14	71.63	37.83	2709.76
13	58.14	28.23	1641.29
15	44.32	40.08	1776.35

13	53.92	24.39	1315.11
7	41.41	30.59	1266.73
8	45.08	18.11	816.40
2	34.39	29.67	1020.35
0	18.65	12.57	234.43
0	36.18	13.18	476.85
0	12.15	6.72	81.65
0	6.17	5.32	32.82
0	8.21	3.63	29.80
3	20.15	12.43	250.46
7	48.61	19.96	970.26
5	31.57	22.5	710.33
3	43.34	13.53	586.39
4	27.8	14.39	400.04
4	39.52	18.24	720.84
4	41.6	14.07	585.31
1	26.58	17.37	461.69
2	24.6	18.11	445.51
2	22.34	14.79	330.41
0	27.38	15.46	423.29
0	21	14.62	307.02
0	19.44	10.76	209.17
0	11.45	11.12	127.32
0	19.42	9.69	188.18
0	19.33	7.96	153.87
0	16.21	12.05	195.33
4	43.98	24.05	1057.72
13	48.31	28.11	1357.99
7	48.68	28.38	1381.54
4	32.68	24.02	784.97
2	36.01	14.81	533.31
0	17.61	15.4	271.19
0	20.12	12.09	243.25
0	15.33	7.68	117.73
0	11.99	11.61	139.20
0	11.72	11.29	132.32
2	42.28	13.04	551.33
4	33.42	21.26	710.51
3	35.46	16.43	582.61
5	42.34	26.09	1104.65
2	23.54	18.47	434.78
0	35.18	9	316.62
0	22.85	15.43	352.58
0	18.65	12.4	231.26
0	16.25	9.12	148.20
0	16.49	10.25	169.02
0	22.3	9.71	216.53
6	38.97	28.03	1092.33
7	44.12	23.79	1049.61
5	36.34	22.91	832.55
3	26.17	20.94	548.00
1	26.3	16.62	437.11
0	20.35	9.69	197.19
0	15.92	7.25	115.42
0	16.64	12.26	204.01
27	58.01	45.4	2633.65
7	40.81	20.41	832.93

4	30.98	15.94	493.82	12	60.87	29.06	1768.88
5	27.53	19.98	550.05	22	62.48	38.73	2419.85
2	38.65	19.84	766.82	10	41.3	35.96	1485.15
3	32.44	24.82	805.16	7	54.08	20.72	1120.54
0	23.41	13.77	322.36	20	71.63	41.82	2995.57
0	34.43	21.63	744.72	29	55.12	49.11	2706.94
0	37.96	13.34	506.39	6	46.59	30.91	1440.10
0	20.59	10.84	223.20	12	52.93	26.24	1388.88
0	15.13	10.14	153.42	14	38.01	35.45	1347.45
0	17.75	11.64	206.61	4	40.96	24.82	1016.63
0	13.31	10.86	144.55	3	34.15	19	648.85
0	19.4	5.27	102.24	5	41.81	21.56	901.42
12	41.83	37.45	1566.53	5	43.01	20.82	895.47
5	28.84	28.43	819.92	10	32.02	22.07	706.68
4	35.27	15.92	561.50	4	37.39	28.98	1083.56
4	39.33	19.4	763.00	9	56.58	25.31	1432.04
3	37.66	14.77	556.24	7	43.82	29.58	1296.20
3	22.22	16.77	372.63	5	34.92	19.55	682.69
0	23.23	14.34	333.12	6	40.07	20.52	822.24
0	22.1	14.42	318.68	4	46.21	21.12	975.96
0	18.21	14.11	256.94	4	32.45	23.79	771.99
0	15.84	8.02	127.04	5	37.29	27.94	1041.88
0	17.66	9.03	159.47	4	31.83	18.74	596.49
0	19.11	9.4	179.63	5	39.32	23.02	905.15
0	13.42	9.35	125.48	4	33.54	31.53	1057.52
0	15.83	6.74	106.69	5	36.75	24.92	915.81
0	19.67	11.15	219.32	6	44.7	23.84	1065.65
6	54.47	16.34	890.04	7	29.22	29.05	848.84
9	54.17	18.76	1016.23	4	44.43	13.92	618.47
5	30.45	21.66	659.55	26	56.25	38.22	2149.88
4	29.67	20.56	610.02	14	56.05	31.89	1787.43
4	41.28	25.38	1047.69	7	51.24	33.25	1703.73
6	46.05	23.38	1076.65	5	31.38	30.42	954.58
5	42.19	26.56	1120.57	9	42.13	33.78	1423.15
4	35.67	17.22	614.24	4	52.48	16.02	840.73
4	41	13.06	535.46	7	30.69	28.86	885.71
6	35.05	29.26	1025.56	6	37.51	18.36	688.68
12	47.99	34.57	1659.01	4	45.14	12.92	583.21
43	72.59	48.83	3544.57	9	38.71	28.14	1089.30
28	60.02	44.14	2649.28	10	38.34	39.74	1523.63
43	74.5	52.93	3943.29	3	34.9	17.44	608.66
18	55.59	41.64	2314.77	7	48.08	27.41	1317.87
15	52.58	31.97	1680.98	5	38.28	21.56	825.32
9	52.93	24.94	1320.07	7	37.37	25.38	948.45
23	69.53	36.39	2530.20	5	34.55	22.49	777.03
9	44.72	29.01	1297.33	5	39.29	26.7	1049.04
7	39.6	25.38	1005.05	3	36.91	29.88	1102.87
10	48.63	24.56	1194.35	4	37.2	23.59	877.55
26	62.17	35.29	2193.98	4	31.78	26.56	844.08
10	48.61	28.97	1408.23	7	37.21	27.93	1039.28
4	35.29	23.22	819.43	7	45.62	19.97	911.03
7	40.12	32.83	1317.14	4	29.35	24.94	731.99
54	100.02	56.84	5685.14	4	33.72	31.6	1065.55
16	59.01	39.61	2337.39	4	40.6	18.04	732.42
26	52.02	42.74	2223.33	7	35.27	16.97	598.53
11	55.06	35.81	1971.70	5	43.54	25.64	1116.37
9	53.58	24.72	1324.50	6	37.05	26.43	979.23

3	30.49	23.28	709.81
5	37.33	22.01	821.63
4	42.72	21.05	899.26
5	32.94	19.56	644.31

4	33.28	20.15	670.59
2	32.29	23.84	769.79
5	32.61	20.48	667.85
4	28.74	26.46	760.46

3	27.75	22.55	625.76
3	36.46	15.19	553.83
3	34.99	18.51	647.66
4	38.5	22.56	868.56
3	43.47	25.52	1109.35
4	39.58	23.4	926.17
6	30.67	27.38	839.74
4	39.86	22.6	900.84
4	41.92	19.88	833.37
7	41.12	27.83	1144.37
3	28.58	23.7	677.35
3	29.02	16.98	492.76
4	27.74	20.33	563.95
4	34.36	17.4	597.86
4	42.61	17.62	750.79
6	33.8	26.19	885.22
4	35.58	18.56	660.36
7	64.6	16.95	1094.97
5	39.84	21.24	846.20
6	37.38	23.68	885.16
4	34.99	21.71	759.63
4	31.27	20.3	634.78
6	32.02	15.22	487.34
15	51.21	25.01	1280.76
5	48.6	33.16	1611.58
7	37.58	27.19	1021.80
7	43.11	24.27	1046.28
10	49.32	30.47	1502.78
48	67.88	44.78	3039.67
4	45.96	27.62	1269.42
10	42.21	20.69	873.32
4	48.73	14.81	721.69
7	42.85	27.42	1174.95
7	48.89	23.08	1128.38
3	35.33	14.44	510.17
0	18.57	14.13	262.39
3	38.95	13.34	519.59
3	33.69	20.81	701.09
4	38.46	20.11	773.43
4	36.6	29.55	1081.53
10	46.63	28.55	1331.29
4	37.5	21.68	813.00
6	50.79	26.79	1360.66
6	44.41	25.46	1130.68
3	30.66	28.54	875.04
5	27.17	25.11	682.24
7	38.2	24.88	950.42
10	43.9	33.5	1470.65
4	37.22	24.13	898.12
12	54.09	34.82	1883.41
4	29.68	21.51	638.42

7	41.7	26.23	1093.79
10	49.01	30.11	1475.69
10	31.36	27.97	877.14
7	50.7	24.68	1251.28
8	46.3	31.95	1479.29
3	36.78	19.32	710.59
1	30.41	13.69	416.31
4	24.41	24.28	592.67
4	49.63	21.24	1054.14
5	41.6	31.46	1308.74
8	51.74	25.42	1315.23
7	43.1	18.69	805.54
2	27.27	19.67	536.40
3	37.59	22.27	837.13
5	42.26	25.32	1070.02
7	67.08	18.53	1242.99
7	32.91	25.37	834.93
5	34.32	27.11	930.42
4	33.2	24.38	809.42
5	36.22	16.89	611.76
2	34.91	15.35	535.87
2	36.17	18.24	659.74
5	30.49	30.25	922.32
4	34.28	14.82	508.03
4	40.61	14.44	586.41
5	55.95	14.38	804.56
1	33.66	19.9	669.83
2	26.41	16.8	443.69
11	35.33	28.96	1023.16
7	34.22	31.86	1090.25
6	45.82	28.66	1313.20
5	42.3	27.8	1175.94
4	28.27	21.4	604.98
3	29.5	22.4	660.80
4	28.49	18.48	526.50
3	29.97	18.13	543.36
7	38.59	24.8	957.03
5	40.7	19.33	786.73
4	39.3	20.34	799.36
4	37.16	15.86	589.36
4	36.06	30.13	1086.49
8	36.91	29.44	1086.63
5	35.64	25.24	899.55
6	26.36	24.47	645.03
4	37.2	22.83	849.28
3	34.22	19.66	672.77
3	28.61	24.46	699.80
4	27.34	25.03	684.32
3	23.85	22.48	536.15
2	25.92	21.95	568.94
4	42.54	16.39	697.23

3	28.88	20.34	587.42
2	24.37	20.5	499.59
2	39.5	15.32	605.14
1	36.26	15.13	548.61
2	34.82	16.64	579.40
0	28.51	16.72	476.69
2	44.2	14.53	642.23
4	28.63	19.94	570.88
0	33.46	9.49	317.54
3	30.5	19.28	588.04
1	18.23	15.98	291.32
5	29.82	23.1	688.84
3	26.88	18.78	504.81
3	23.28	18.9	439.99
4	28.17	17.08	481.14
2	31.29	17.88	559.47
2	23.48	20.64	484.63
1	29.29	20.65	604.84
1	21.53	21.07	453.64
1	34.33	16.27	558.55
2	31.57	16.69	526.90
1	33.84	14.18	479.85
0	34.2	11.16	381.67
1	19.56	13.95	272.86
0	19.64	11.62	228.22
0	15.17	12.74	193.27
0	21.3	13.93	296.71
4	34.78	16.46	572.48
3	34.97	21.42	749.06
7	37.95	28.3	1073.99
2	31.12	16.15	502.59
2	29.72	28.32	841.67
2	39.97	17.02	680.29
5	30.49	29.03	885.12
4	32.75	16.94	554.79
5	49.89	20.73	1034.22
2	21.57	19.68	424.50
6	41.48	25.88	1073.50
4	30.51	23.87	728.27
5	57.94	19.33	1119.98
4	39.34	14.6	574.36
7	34.49	28.05	967.44
9	54.71	32.81	1795.04
4	34.01	24.43	830.86
3	39.59	18.56	734.79
3	46.72	21.96	1025.97
7	36.74	17.68	649.56
2	39.29	13.78	541.42
5	31.11	26.92	837.48
2	38.41	20.55	789.33
3	25.77	22.31	574.93
3	33.19	19.64	651.85
4	49.55	15.53	769.51
3	30.99	17.42	539.85
5	40.93	21.64	885.73
5	48.35	18.33	886.26
2	26.97	21.67	584.44

2	26.7	18.38	490.75
5	37.26	27.09	1009.37
3	35.49	19.66	697.73
2	33.16	12.96	429.75
6	36.41	32.74	1192.06
3	34.77	17.13	595.61
6	36.88	22.87	843.45
3	29.56	21.05	622.24
7	45.48	16.68	758.61
4	42.55	20.04	852.70
3	31.68	20.77	657.99
4	26.38	23.14	610.43
3	32.7	18.3	598.41
4	31.65	16.26	514.63
2	27.92	17.16	479.11
3	43.15	15.47	667.53
3	34.77	20.59	715.91
2	27.98	16.15	451.88
2	43.41	13.19	572.58
2	26.5	22.11	585.92
2	29.07	23.19	674.13
3	38.03	11.88	451.80
3	43.32	12.46	539.77
4	25.23	22.79	574.99
3	33.56	13.8	463.13
5	25.55	24.23	619.08
4	38.29	26.66	1020.81
6	49.52	29.3	1450.94
5	32.68	20.26	662.10
3	33.01	24.55	810.40
2	39.38	14.13	556.44
4	48.93	20.04	980.56
3	45.11	15	676.65
2	29.22	19.29	563.65
3	27.36	22.68	620.52
4	30.92	19.35	598.30
2	43.18	12.43	536.73
2	26.99	21.86	590.00
5	42.67	12.48	532.52
4	25.14	24.37	612.66
6	41.55	23.93	994.29
4	31.48	13.83	435.37
1	27.06	11.14	301.45
4	36.21	14.82	536.63
3	27.62	20.4	563.45
2	26.71	21.5	574.27
2	31.72	17.44	553.20
2	39.71	15.48	614.71
3	23.57	20.51	483.42
4	27.68	20.9	578.51
2	26.79	21.15	566.61
2	32.2	16.34	526.15
4	32.16	17.99	578.56
3	33.79	18.1	611.60
2	26.72	17.62	470.81
2	39.27	18.56	728.85
2	41.88	17.33	725.78

2	40.82	15.46	631.08
2	23.69	20.83	493.46
0	25.42	14.88	378.25
1	40.03	15.17	607.26
2	29.78	16.71	497.62
3	24.48	21.59	528.52
2	28.92	15.48	447.68
2	27.65	23.13	639.54
2	26.8	18.52	496.34
1	31.13	15.4	479.40
1	32.23	15.53	500.53
0	30.82	12.29	378.78
2	21.43	20.77	445.10
1	31.1	14.67	456.24
2	24.62	21.37	526.13
5	34.11	26.73	911.76
3	24.26	19.02	461.43
4	30.29	22.34	676.68
5	35.68	28.31	1010.10
3	37.12	16.92	628.07
5	33.24	23.15	769.51
3	31.62	26.42	835.40
5	32.61	20.7	675.03
0	38.11	18.74	714.18
4	30.74	16.9	519.51
2	26.01	19.12	497.31
3	25.07	22.31	559.31
2	31.74	14.78	469.12
2	28.47	17.67	503.06
2	35.65	16.88	601.77
1	29.66	18.48	548.12
3	31.11	21.51	669.18
1	27.49	18.07	496.74
2	32.72	14.64	479.02
2	32.99	23.65	780.21
4	37.42	17.64	660.09
1	29.1	13.9	404.49
2	35.73	17.23	615.63
3	32.6	16.27	530.40
3	42.71	14.65	625.70
3	23.41	19.09	446.90
3	35.68	14.62	521.64
1	37.93	19.49	739.26
3	34.9	14.71	513.38
2	22.4	17.43	390.43
1	21.18	19.13	405.17
3	37.21	16.37	609.13
2	28.49	21.26	605.70
2	33.64	19.39	652.28
3	32.98	22.45	740.40
1	31.97	17.97	574.50
3	30.63	15.51	475.07
3	24.22	21.5	520.73
2	23.45	23.41	548.96
2	34.27	22.27	763.19
1	34.81	12.09	420.85
3	29.62	18.53	548.86

3	36.28	21.2	769.14
1	31.85	14.2	452.27
2	27.81	15.32	426.05
2	32.11	11.83	379.86
3	30.6	17.7	541.62
2	30.42	17.31	526.57
2	30.15	15.78	475.77
2	38.23	14.75	563.89
1	26.52	18.74	496.98
3	34.53	15.78	544.88
2	35.26	16.6	585.32
2	23.58	20.72	488.58
4	25.48	23.38	595.72
3	32.09	17.64	566.07
1	28.91	15.75	455.33
1	20.61	20.37	419.83
2	33.95	17.09	580.21
3	30.02	14.93	448.20
2	25.57	17.34	443.38
1	17.89	17.54	313.79
0	23.48	17.87	419.59
2	30.18	12.15	366.69
3	18	17.97	323.46
1	35.9	14.98	537.78
1	30.64	15.23	466.65
0	30.12	13.56	408.43
3	26.93	23.09	621.81
1	26.14	14.84	387.92
0	29.9	16.13	482.29
2	20.07	10.54	211.54
1	24.21	14.49	350.80
1	39.49	11.21	442.68
1	29.96	14	419.44
1	19.34	17.4	336.52
1	22.18	18.62	412.99
1	23.61	17.55	414.36
1	27.61	13.38	369.42
2	26.33	18.48	486.58
1	28.15	13.74	386.78
2	24.42	16.97	414.41
1	22.88	17.72	405.43
0	18.42	11.51	212.01
0	27.14	13.01	353.09
0	20.01	16.93	338.77
1	26.14	16.41	428.96
0	19.17	8.39	160.84
0	26.07	16.32	425.46
2	19.69	16.16	318.19
4	23.14	16.17	374.17
1	25.18	18.92	476.41
2	24.45	19.68	481.18
1	31.89	13.88	442.63
1	25.8	11.03	284.57
0	19.76	13.12	259.25
0	18.87	9.77	184.36
0	14.6	9.27	135.34
1	22.88	15.09	345.26

0	30.86	13.84	427.10
2	24.29	16.5	400.79
2	25.39	17.67	448.64
2	22.89	12.81	293.22
2	33.09	14.15	468.22
2	25.53	16.88	430.95

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Weight (g)	Length (mm)	Width (mm)	Surface Area (mm)
12	42.01	32.76	1376.25
80	112.46	61.17	6879.18
235	129.3	118.01	15258.69
214	138.25	102.19	14127.77
135	103.63	100.92	10458.34
249	163.4	116.26	18996.88
216	137.81	121.45	16737.02
251	182.95	128	23417.60
114	117.18	73.57	8620.93
68	92.08	71.26	6561.62
235	164	97.28	15953.92
81	115.14	71.3	8209.48
186	102.36	91.07	9321.93
65	92.77	84.28	7818.66
48	77.97	66.85	5212.29
43	80.95	56.62	4583.39
48	72.05	67	4827.35
56	83.82	54.13	4537.18
92	94.48	85.5	8078.04
32	93	57.24	5323.32
57	89.05	59.97	5340.33
30	99.29	52.03	5166.06
167	121.76	100.13	12191.83
170	181	107.84	19519.04
47	88.28	57.44	5070.80
9	63.51	37.28	2367.65
44	67.19	49.36	3316.50
22	72.68	40.03	2909.38
80	103.48	68.86	7125.63
35	95.51	33.47	3196.72
108	141.85	59.38	8423.05
91	94.7	68.22	6460.43
24	96.4	24.09	2322.28
28	65.61	43.79	2873.06
13	51.58	39.98	2062.17
9	35	31.25	1093.75
23	65.4	29.36	1920.14
66	121.18	68.37	8285.08
16	58.94	34.56	2036.97
51	82.78	45.95	3803.74
11	60.94	29.54	1800.17
15	52.33	26.62	1393.02

3	24.09	18.78	452.41
1	23.29	19.77	460.44
2	30.01	15.05	451.65
4	33.24	19.03	632.56
3	34.08	15.8	538.46

29	79.19	41.8	3310.14
8	54.12	37.55	2032.21
18	62.73	34.22	2146.62
29	58.35	41.56	2425.03
23	55.93	53.47	2990.58
51	68.96	51.88	3577.64
50	90.02	56.73	5106.83
18	63.51	32.67	2074.87
131	152.11	70.74	10760.26
296	162	115.92	18779.04
54	77.45	62.1	4809.65
253	127.2	112.77	14344.34
72	105.19	73.97	7780.90
144	112.3	87.18	9790.31
21	60.25	36.78	2216.00
80	70.19	56.51	3966.44
77	95.04	67.16	6382.89
22	70.25	46.39	3258.90
12	47.93	40.2	1926.79
121	90.25	74.8	6750.70
7	40.02	24.75	990.50
14	48.38	36.05	1744.10
13	38.84	34.87	1354.35
61	100.65	91.18	9177.27
16	48.19	44.86	2161.80
21	61.9	41.62	2576.28
11	42.54	35.33	1502.94
18	69.28	26.44	1831.76
8	51.43	25.37	1304.78
54	102.06	51.95	5302.02
46	106.87	44.96	4804.88
85	107.16	75.86	8129.16
23	69.4	48.86	3390.88
36	54.65	54.13	2958.20
8	58.5	29.42	1721.07
20	57.36	41.75	2394.78
23	49.59	43.84	2174.03
29	70.95	32.75	2323.61
26	92.91	47.57	4419.73
34	68.14	53.24	3627.77
23	58.34	45.96	2681.31
12	44.57	34.14	1521.62
45	64.4	61.17	3939.35
5	46.05	32.33	1488.80
13	51.85	31.55	1635.87
7	49.4	31.33	1547.70
14	61.75	32.06	1979.71
19	59.74	47.84	2857.96
105	80.64	52.71	4250.53
68	89.69	52.57	4715.00

9	76.38	23.65	1806.39
2	30.05	22.36	671.92
12	63.3	40.61	2570.61
18	70.23	28.62	2009.98
12	63.12	30.37	1916.95
15	55.98	31.28	1751.05
110	140.37	43.07	6045.74
5	37	29.95	1108.15
13	39.61	38.92	1541.62
15	45.28	40.02	1812.11
18	69.94	42.27	2956.36
20	62.23	41.59	2588.15
25	79.84	48.96	3908.97
36	96.56	63.09	6091.97
15	48.09	29.68	1427.31
8	61.82	20.91	1292.66
15	51.36	28.78	1478.14
12	50.29	30.75	1546.42
6	35.89	22.59	810.76
7	50.32	25.74	1295.24
10	42.87	31.64	1356.41
7	42.63	27.18	1158.68
4	41.56	23.13	961.28
7	48.3	25.62	1237.45
4	41.34	37.26	1540.33
11	44.95	43.69	1963.87
5	20.26	12.19	246.97
8	36.05	33.41	1204.43
8	42.56	31.53	1341.92
7	45.28	23.48	1063.17
9	48.55	23.62	1146.75
12	51.3	38.42	1970.95
14	53.29	36.44	1941.89
5	33.74	27.48	927.18
3	43.09	27.96	1204.80
5	50.51	21.72	1097.08
5	34.32	24.24	831.92
9	48.19	26.37	1270.77
7	48.92	25.81	1262.63
21	68.79	40.64	2795.63
38	79.15	48.43	3833.23
28	78.48	43.31	3398.97
27	51.12	39.8	2034.58
11	57.16	30.69	1754.24
9	41.53	34.16	1418.66
3	31.66	17.15	542.97
24	60.06	40.48	2431.23
8	31.09	29.83	927.41
4	44.42	16.38	727.60
5	45.84	21.85	1001.60
7	48.57	31.72	1540.64
9	43.61	28.06	1223.70
8	33.69	25.36	854.38
16	72.61	33.32	2419.37
7	37.12	27.63	1025.63
5	39.21	28.9	1133.17
4	48.17	17.75	855.02

6	40.95	29.26	1198.20
7	40.29	22.75	916.60
4	39.22	27.1	1062.86
7	50.83	23.23	1180.78
29	78.01	41.74	3256.14
8	41.52	36.23	1504.27
31	81.28	41.57	3378.81
16	56.43	30.55	1723.94
33	77.12	32.47	2504.09
9	41.17	39.23	1615.10
7	37.63	29.08	1094.28
6	31.51	26.65	839.74
4	54.79	21.13	1157.71
4	39.67	25.8	1023.49
8	47.42	28.18	1336.30
7	46.34	22.22	1029.67
6	35.66	27.91	995.27
4	39.5	24.63	972.89
10	61.77	30.76	1900.05
5	48.87	19.61	958.34
7	47.48	24.59	1167.53
13	90.94	33.59	3054.67
7	38.45	23.3	895.89
3	40.57	15.73	638.17
5	35.77	28.13	1006.21
118	157	59.9	9404.30
22	53.9	42.44	2287.52
13	47.78	46.44	2218.90
44	85.8	46.68	4005.14
10	42.81	38.5	1648.19
5	58.91	24.39	1436.81
11	54.5	26.07	1420.82
4	26.02	27.05	703.84
4	40.9	28.92	1182.83
7	33.56	31.9	1070.56
6	46.08	23.15	1066.75
7	40.12	27.21	1091.67
7	32.71	28.64	936.81
7	50.99	28.08	1431.80
18	71.33	48.97	3493.03
70	129.39	47.95	6204.25
20	53.93	33.55	1809.35
63	102.25	65.51	6698.40
22	57.38	50.56	2901.13
13	55.38	37.95	2101.67
16	59.86	31.42	1880.80
13	67.56	33.51	2263.94
10	50.6	32.3	1634.38
10	37.59	31.69	1191.23
7	49.95	25.73	1285.21
33	62.51	45.22	2826.70
11	45.72	38.87	1777.14
11	46.29	37.35	1728.93
6	47.54	27.29	1297.37
5	48.17	27.01	1301.07
4	38.58	24.12	930.55
13	47.11	44.04	2074.72

4	37.57	19.5	732.62
10	39.37	35.3	1389.76
5	37.39	27.77	1038.32
8	37.74	34.15	1288.82
18	59.38	45.45	2698.82
12	77.19	27.12	2093.39
4	38.08	28.77	1095.56
4	48.38	27.22	1316.90
7	47.8	20.51	980.38
19	55.06	38.42	2115.41
8	37.49	21.45	804.16
5	32.62	26.58	867.04
4	30.68	28.13	863.03
5	32.33	28.51	921.73
3	26.73	27.46	734.01
5	42.44	25.5	1082.22
5	50	17.66	883.00
4	47.1	24.03	1131.81
4	33.59	24.12	810.19
7	34.69	28.58	991.44
3	50.82	13.3	675.91
13	52.95	40.27	2132.30
5	52.06	21.93	1141.68
9	40.78	26.45	1078.63
10	57.13	32.12	1835.02
9	47.02	34.24	1609.96
7	36.95	27.56	1018.34
6	30.65	28.89	885.48
5	30.66	27.01	828.13
9	67.59	19.06	1288.27
8	36.37	29.27	1064.55
9	58.75	31.43	1846.51
7	35.78	27.56	986.10
8	57.05	16.07	916.79
12	71.91	30.22	2173.12
111	111.93	94.05	10527.02
18	69.36	36.3	2517.77
73	83.4	42.45	3540.33
41	69.66	49.6	3455.14
41	91.8	56.32	5170.18
18	76.77	34.86	2676.20
27	73.26	52.3	3831.50
25	65.73	38.15	2507.60
11	56.3	35.77	2013.85
7	55.46	21.8	1209.03
9	55.44	32.42	1797.36
9	42.42	35.52	1506.76
9	40.35	34.7	1400.15
9	43.66	36.83	1608.00
14	40.33	34.47	1390.18
12	62.25	31.13	1937.84
7	47.4	32.62	1546.19
10	50.59	25.51	1290.55
9	36	35.91	1292.76
10	45.42	33.3	1512.49
4	39.9	22.61	902.14
4	49.32	21.45	1057.91

5	36.83	27.16	1000.30
22	69.27	54.14	3750.28
46	105.4	36.66	3863.96
27	51.59	46.53	2400.48
31	72	35.47	2553.84
4	39.45	25.66	1012.29
7	40.66	37.52	1525.56
10	50.21	33.86	1700.11
7	50.36	28.93	1456.91
9	49.58	13.14	651.48
21	58.03	40.52	2351.38
4	37.81	21.43	810.27
6	48.7	18.61	906.31
7	36.9	21.04	776.38
4	31.04	29.01	900.47
5	39.91	27.89	1113.09
3	30.78	24.5	754.11
4	35.44	24.81	879.27
7	37.87	30.97	1172.83
7	41.16	32.99	1357.87
10	57.78	32.49	1877.27
6	39.74	27.14	1078.54
4	37.7	28.38	1069.93
5	54.2	8.6	466.12
10	47.28	28.39	1342.28
7	40.97	18.31	750.16
4	36.48	23.21	846.70
3	33.9	15.67	531.21
4	33.45	28.61	957.00
5	38.78	35.17	1363.89
5	43.95	19.74	867.57
5	36.25	27.19	985.64
4	44.75	21.08	943.33
21	70.8	31.56	2234.45
19	53	31.34	1661.02
7	56.52	34.7	1961.24
8	44.3	28	1240.40
42	69.21	49.44	3421.74
8	43.12	40.82	1760.16
10	60.47	28.71	1736.09
4	34.76	20.64	717.45
3	40.56	18.72	759.28
4	33.97	27.56	936.21
5	41.84	23	962.32
4	34.9	25.17	878.43
4	60.95	19.82	1208.03
4	33.88	27.25	923.23
4	49.76	24.83	1235.54
7	39.74	25.05	995.49
5	43.98	23.74	1044.09
9	42.38	29.01	1229.44
4	32.08	25.77	826.70
10	29.51	23.93	706.17
6	26.85	22.49	603.86
4	33.79	20.98	708.91
3	28.43	21.3	605.56
5	31.35	19.74	618.85

5	46.32	14.75	683.22
6	30.38	24.35	739.75
3	40.44	24.59	994.42
2	38.56	25.05	965.93
2	45.2	14.16	640.03
4	34.5	21.92	756.24
5	36.83	15.21	560.18
3	27.96	21.33	596.39
4	28.98	20.35	589.74
5	29.65	21.13	626.50
4	40.06	20.68	828.44
4	39.54	17.12	676.92
3	31.5	22.71	715.37
3	29.56	23.73	701.46
7	41.68	22.3	929.46
5	45.32	16.86	764.10
4	36.76	18.96	696.97
5	34.27	33.19	1137.42
2	34.1	18.6	634.26
3	37.27	18.77	699.56
2	24.03	23.72	569.99
5	44.3	16.76	742.47
4	43.77	16.89	739.28
4	34.34	27.52	945.04
4	30.42	24.14	734.34
3	43.81	17	744.77
4	27.14	24.16	655.70
3	41.52	18.12	752.34
4	37.64	28.58	1075.75
3	35.05	16.2	567.81
5	47.11	17.78	837.62
7	42.9	17.28	741.31
3	35.5	22.19	787.75
4	39.44	23.52	927.63
2	37.42	19.95	746.53
4	38.6	14.18	547.35
77	159	52.17	8295.03
37	56.99	51.98	2962.34
12	57.25	33.8	1935.05
27	61.29	44.04	2699.21
19	63.37	35.52	2250.90
9	53.59	22.05	1181.66
11	48.51	34.27	1662.44
6	38.71	29.21	1130.72
8	48.45	23.61	1143.90
6	38.28	21.34	816.90
10	44.98	26.31	1183.42
11	52.16	18.38	958.70
15	48.87	33.73	1648.39
12	43.23	31.62	1366.93
6	47.73	27.31	1303.51
4	40.17	17.27	693.74
8	36.74	27.61	1014.39
5	40.99	21.65	887.43
18	52.47	40.22	2110.34
4	35.58	25.99	924.72
2	44.72	16.65	744.59

4	51.77	21.92	1134.80
5	35.94	25.28	908.56
4	35.52	21.56	765.81
4	43.97	23.59	1037.25
2	39.16	21.01	822.75
4	28.83	26.34	759.38
4	41.2	16.08	662.50
4	26.69	23.62	630.42
4	31.3	22.35	699.56
6	44.89	18.02	808.92
6	33.02	28.4	937.77
4	33.11	21.93	726.10
3	25.05	16.02	401.30
4	35.9	19.53	701.13
4	33.77	25.12	848.30
2	26.42	14.17	374.37
4	41.67	17.6	733.39
4	26.44	25.6	676.86
7	41.48	21.5	891.82
7	39.87	27.8	1108.39
4	27.05	25	676.25
2	21.9	19.98	437.56
3	23.5	22.12	519.82
3	22.13	20.11	445.03
4	31.98	21.72	694.61
3	30.63	20.68	633.43
2	29.85	19.12	570.73
4	34.03	22.65	770.78
3	36.92	20.8	767.94
3	31.76	20.66	656.16
3	29.34	14.36	421.32
2	35.21	17.02	599.27
5	32.14	22.39	719.61
3	40.53	22.93	929.35
3	35.33	21.62	763.83
3	33.04	21.42	707.72
1	33.68	12.64	425.72
2	40.67	14.57	592.56
2	32.59	17.9	583.36
4	32.89	18.02	592.68
3	33.38	24.77	826.82
16	39.8	38.23	1521.55
4	36.94	23.58	871.05
5	40.01	20.99	839.81
3	32	17.43	557.76
6	33.94	27.65	938.44
4	32.94	27.04	890.70
5	31.51	26.82	845.10
1	28.35	23.88	677.00
4	34.21	25.89	885.70
4	27.83	23.96	666.81
3	29.13	23.35	680.19
7	35.98	28.99	1043.06
5	43.49	21.7	943.73
4	30.65	20.56	630.16
5	39.22	24.39	956.58
4	34.35	25.32	869.74

3	35.53	25.11	892.16
3	34.54	21.12	729.48
3	38.56	18.33	706.80
4	38.96	17.43	679.07
3	35.23	19.74	695.44
4	33.08	23.53	778.37
5	32.71	19.16	626.72
5	31.99	25.77	824.38
4	25.92	23.88	618.97
2	39.62	16.09	637.49
4	48.95	17.62	862.50
3	37.59	18.43	692.78
2	33.87	18.15	614.74
5	43.02	28.21	1213.59
3	38.88	20.9	812.59
4	29.07	25.77	749.13
3	39.09	18.45	721.21
2	27.67	16.63	460.15
4	26.72	26.26	701.67
5	33.01	25.48	841.09
3	41.51	20.59	854.69
3	29.11	14.74	429.08
2	34.76	16.88	586.75
4	28.64	25.15	720.30
3	31.49	14.25	448.73
1	31.88	18.18	579.58
4	30.42	23.96	728.86
2	33.61	16.15	542.80
2	34.21	16.38	560.36
1	25.08	15.91	399.02
2	29.2	17.65	515.38
2	31.27	17.22	538.47
2	31.69	17.04	540.00
2	30.22	20.84	629.78
2	36.44	17.02	620.21
3	33.9	19.77	670.20
3	29.79	18.11	539.50
1	28.85	20.73	598.06
1	41.79	11.18	467.21
3	30.83	13.38	412.51
1	33.02	17.26	569.93
1	24.54	17.25	423.32
2	29.8	19.9	593.02
3	29.62	20.05	593.88
3	27.1	22.09	598.64
2	30.25	21.22	641.91
3	40.63	12	487.56
2	21.49	14.96	321.49
4	26.59	24.4	648.80
2	33.57	15.37	515.97
3	35.96	19.89	715.24
4	35.57	19.61	697.53
1	40.46	17.92	725.04
3	29.84	23	686.32
3	30.69	25.37	778.61
3	33.23	21.65	719.43
1	30.98	21.95	680.01

3	36.87	20.13	742.19
2	37.65	18.93	712.71
2	29.05	14.31	415.71
3	34.49	17.84	615.30
2	31.39	14.49	454.84
3	38.85	22.15	860.53
3	24.99	18.75	468.56
3	37.08	18.26	677.08
4	27.72	22.88	634.23
1	28.75	14.95	429.81
2	32.74	18.5	605.69
2	27.57	19.13	527.41
1	17.43	17.23	300.32
1	25.29	16.44	415.77
4	33.82	18.64	630.40
6	45.49	21.33	970.30
5	35.52	30.25	1074.48
3	29.04	18.61	540.43
1	26.68	16.3	434.88
0	25.65	19.05	488.63
2	30.72	18.69	574.16
4	28.78	22.11	636.33
3	33.4	22.03	735.80
4	32.58	16.82	548.00
3	30.88	16.16	499.02
2	26.25	18.47	484.84
1	29.17	18.36	535.56
1	38.75	13.17	510.34
1	20.06	16.64	333.80
2	28.33	16.58	469.71
1	38.19	14.74	562.92
3	34.52	21.81	752.88
2	40.44	13.71	554.43
3	30.44	22.27	677.90
4	31.04	22.1	685.98
3	26.99	23.2	626.17
4	33.89	16.69	565.62
3	29.44	22.93	675.06
0	22.85	19.33	441.69
2	42.31	15.91	673.15
1	27.24	18.89	514.56
0	36.62	14.85	543.81
1	28.02	19.11	535.46
0	20.76	18.2	377.83
3	34.78	20.36	708.12
2	35.82	17.5	626.85
3	46.23	20.06	927.37
4	32.9	21.9	720.51
5	38.72	27.12	1050.09
3	43.03	17.82	766.79
4	34.28	23.77	814.84
3	26.63	20.52	546.45
3	23.56	21.79	513.37
1	26.26	17.67	464.01
2	24.89	17.13	426.37
4	26.12	21.47	560.80
2	29.72	25.59	760.53

1	23.27	17.09	397.68
1	29.97	17.15	513.99
2	23.86	15.63	372.93
3	26.69	19.86	530.06
3	30.95	12.59	389.66
2	32.56	13.04	424.58
3	36.57	16.59	606.70
4	28.8	18.77	540.58
4	31.95	18.75	599.06
3	20.63	17.6	363.09
2	30.54	15.63	477.34
3	28.79	9.54	274.66
4	26.5	14.56	385.84
0	20.05	19.1	382.96
1	33.38	14	467.32
2	22.24	21.88	486.61
0	26.86	15.25	409.62
2	25.51	19.59	499.74
2	28.33	16.45	466.03
5	29.56	25.82	763.24
2	34.54	18.36	634.15
3	22.15	21.41	474.23
2	27.06	16.02	433.50
3	36.45	14.81	539.82
2	25.4	19.7	500.38
4	35.87	16.77	601.54
2	27.97	19.24	538.14
3	34.93	19.45	679.39
2	27.55	14.42	397.27
3	24.94	20.62	514.26
3	31.19	20.37	635.34
2	31.2	18.23	568.78
1	28.49	18.72	533.33
1	30.36	14.35	435.67
2	25.74	16.67	429.09
0	22.08	19.13	422.39
1	26.05	16.13	420.19
7	37.71	23.91	901.65
7	36.15	25.96	938.45
1	31.59	29.13	920.22
2	22.81	17.99	410.35
7	22.96	17.82	409.15
3	25.33	20.79	526.61
6	47.19	15.9	750.32
2	32.68	20.7	676.48
2	22.29	17.6	392.30
2	33.46	21.91	733.11
3	25.52	17.88	456.30
3	34.22	21.87	748.39
3	32.81	20.3	666.04
3	34.16	17.49	597.46
2	34.22	16.08	550.26
4	42.42	25.93	1099.95
4	26.31	17.61	463.32
4	35.09	17.2	603.55
3	39.93	14.4	574.99
2	28.32	24.63	697.52

3	32.42	19.64	636.73
4	24.43	15.24	372.31
1	21.25	17.48	371.45
2	22.4	14.01	313.82
0	31.52	14.28	450.11
1	27.49	17.06	468.98
0	25.08	17.88	448.43
1	29.69	14.06	417.44
0	27.26	14.36	391.45
1	31.5	11.2	352.80
16	50.48	41.47	2093.41
17	45.6	36.35	1657.56
5	39.41	19.31	761.01
6	38.33	25.69	984.70
7	51	29.37	1497.87
4	36.63	22.01	806.23
13	35.28	30.15	1063.69
6	41.53	9.35	388.31
8	40.06	31.67	1268.70
4	49.81	25.08	1249.23
6	54.45	20.04	1091.18
5	29.83	24.08	718.31
3	40.96	18.47	756.53
1	22.89	17.12	391.88
2	35.21	16.88	594.34
4	28.42	23.16	658.21
3	24.41	23.68	578.03
0	21.93	18.54	406.58
3	31.04	21.6	670.46
2	21.25	15.77	335.11
4	28.09	21.62	607.31
3	28.65	21.15	605.95
5	35.94	28.43	1021.77
4	31.79	19.32	614.18
9	42.18	27.1	1143.08
3	27.93	20.52	573.12
2	32.74	10.9	356.87
2	27.4	17.58	481.69
1	32.97	19.46	641.60
4	35.54	20.19	717.55
1	28.89	19.65	567.69
2	26.82	17.27	463.18
2	27.7	17.17	475.61
3	32.75	15.4	504.35
3	37.66	13.57	511.05
0	26.45	16.89	446.74
2	31.47	15.22	478.97
2	33.85	12.09	409.25
1	26.37	24.77	653.18
7	38.35	18.09	693.75
2	22.15	17.59	389.62
4	41.31	15.46	638.65
2	27.17	18.22	495.04
2	28.79	15.11	435.02
2	33.98	19.17	651.40
2	25.52	18.77	479.01
1	28.23	21.25	599.89

3	36.23	12.03	435.85
3	26.68	21.37	570.15
2	30.2	17.61	531.82
3	29.13	17.42	507.44
1	23.99	12.36	296.52
3	26.64	18.26	486.45
2	21.3	19.24	409.81
0	23.12	19.74	456.39
2	17.08	17.16	293.09
0	24.66	12.67	312.44
1	17.26	13.94	240.60
1	29.79	15.22	453.40
1	24.55	13.8	338.79
1	20.56	19.55	401.95
2	28.66	14.41	412.99
2	26.74	18.98	507.53
1	21.2	17.8	377.36
1	31.19	17.23	537.40
2	21.16	13.75	290.95
4	29.92	17.55	525.10
1	23.79	18.74	445.82
1	21.16	17.93	379.40
2	29.14	15.95	464.78
5	35.3	21.12	745.54
3	28.01	15.73	440.60
2	28.47	21.4	609.26
0	25.72	14.93	384.00
2	20.21	19.17	387.43
2	29.63	14.61	432.89
3	39.15	13.17	515.61
3	44.34	20.96	929.37
1	25.68	16.92	434.51
2	22.62	19.86	449.23
3	27.43	18.44	505.81
4	32.78	17.1	560.54
4	26.11	17.85	466.06
3	27.73	20.92	580.11
1	32.43	16.49	534.77
2	25.08	17.81	446.67
2	29.48	13.32	392.67
1	21.35	16.66	355.69
1	26.26	19.18	503.67
2	25.37	20.18	511.97
3	21.06	18.77	395.30
3	25.54	20.23	516.67
0	28.44	12.92	367.44
1	28.27	19.59	553.81
1	25.81	16.41	423.54
2	33.06	17.29	571.61
1	29.78	13.8	410.96
1	24.27	16.54	401.43
1	19.75	18.63	367.94
2	36.8	10.44	384.19
2	29.4	16.86	495.68
3	23.84	15.77	375.96
2	30.11	14.88	448.04
4	20.02	18.94	379.18

2	20.66	19.78	408.65
3	37.45	14.34	537.03
1	25.1	18.94	475.39
1	26.98	13.6	366.93
2	35.09	21.06	739.00
1	25.28	15.54	392.85
1	21.99	17.94	394.50
2	31.52	16.83	530.48
1	23.5	14.62	343.57
2	30.8	13.17	405.64
1	22	14.16	311.52
1	20.95	19.02	398.47
2	18.63	18.11	337.39
1	29.68	10.87	322.62
2	21.6	14.82	320.11
2	22.84	16.33	372.98
1	26.63	16.25	432.74
1	26.98	15.48	417.65
1	46.23	12.18	563.08
1	25.36	14.34	363.66
2	17.9	16.26	291.05
1	20.68	18.01	372.45
2	23.69	14.29	338.53
0	24.52	12	294.24
0	23.94	12.35	295.66
0	23.06	14.22	327.91
2	21.23	15.79	335.22
1	21.73	16.36	355.50
0	21.55	16.66	359.02
1	23.02	19.67	452.80
2	21.56	19.52	420.85
0	24.32	12.12	294.76
1	21.91	17.54	384.30
2	19.91	15.86	315.77
1	28.74	12.7	365.00
1	20.74	15.67	325.00
2	21.06	12.62	265.78
4	23.34	15.36	358.50
1	18.16	13.68	248.43
2	20.81	14.05	292.38
0	25.55	12.13	309.92
3	21.55	15.52	334.46
0	17.08	16.44	280.80
1	27.33	14.44	394.65
1	23.94	15.11	361.73
1	24.12	14.02	338.16
1	21.69	12.03	260.93
0	22.57	12.81	289.12
4	30.19	17.58	530.74
3	24.2	21.74	526.11
3	26.46	18.29	483.95
2	22.66	14.76	334.46
2	24.35	12.11	294.88
3	29.54	15.92	470.28
1	18.8	17.08	321.10
0	26.8	17.58	471.14
1	19.82	14.41	285.61

1	30.05	12.46	374.42
1	24.25	14.86	360.36
1	18.17	16.44	298.71
2	43.09	13.8	594.64
1	25.75	19.11	492.08
0	31.33	10.75	336.80
0	29.53	11.79	348.16
2	27.65	13.87	383.51
2	28.13	15.96	448.95
2	24.89	17.61	438.31
1	24.06	17.08	410.94
2	27.65	17.44	482.22
1	35.95	11.78	423.49
1	22.48	13.46	302.58
1	27.74	14.62	405.56
2	21.82	17.22	375.74
2	26.62	14.3	380.67
0	21.91	16.17	354.28
0	22.94	14.99	343.87
0	17.23	15.34	264.31
2	28.54	13.93	397.56
1	21.29	15.14	322.33
1	21.26	15.21	323.36
0	21.88	17.57	384.43
2	31.16	18.94	590.17
1	20.05	14.82	297.14
2	33.71	12.53	422.39
3	27.42	18.51	507.54
0	28.32	19.15	542.33
2	21.31	15.64	333.29
0	31.27	9.6	300.19
1	27.38	11.28	308.85
0	31.15	17.31	539.21
0	28.29	15.21	430.29
1	27.6	10.55	291.18
1	20.62	12.81	264.14
0	25.76	11.58	298.30
0	19.79	16.42	324.95
1	17.01	15.89	270.29
1	23.39	16.23	379.62
1	20.49	13.84	283.58
0	17.76	17.07	303.16
3	25.32	9.21	233.20
2	33.23	10.85	360.55
2	24.77	14.77	365.85
2	23.67	19.79	468.43
1	24.78	11.77	291.66
3	39.27	16.78	658.95
2	24.47	17.37	425.04
2	24.74	17.39	430.23
3	27.76	11.44	317.57
0	18.05	18.02	325.26
1	22.56	13.92	314.04
4	37.54	17.44	654.70
1	25.98	18.1	470.24
1	36.82	9.59	353.10
2	20.95	19.35	405.38

1	26.53	13.08	347.01
2	34.57	13.42	463.93
2	28.83	14.92	430.14
0	27.81	14.33	398.52
4	36.03	17.3	623.32
4	28.24	22.05	622.69
2	24.84	17.18	426.75
6	28.48	24.83	707.16
4	39.91	13.83	551.96
3	24.74	19.22	475.50
2	37.7	18.12	683.12
5	50.42	18.25	920.17
2	25.87	22.85	591.13
2	24.85	22.98	571.05
3	27.04	21.86	591.09
1	35.56	20.54	730.40
2	29.91	14.94	446.86
3	28.36	13.96	395.91
0	21.69	15.82	343.14
1	24.59	22.19	545.65
3	25.54	16.44	419.88
1	27.25	17.03	464.07
1	25.92	16.58	429.75
2	29.22	14.71	429.83
5	44.53	25.18	1121.27
3	22.06	16.06	354.28
2	31.28	17.68	553.03
0	18.96	16.06	304.50
2	32.54	17.61	573.03
3	22.67	21.22	481.06
2	18.79	15.11	283.92
1	24.82	8.58	212.96
1	32.6	8.46	275.80
0	26.82	14.35	384.87
2	25.71	17.69	454.81
0	21.88	17.45	381.81
1	22.97	19.96	458.48
0	21.32	19.54	416.59
0	25.76	17.13	441.27
0	22	12.95	284.90
2	25.21	19.05	480.25
2	33.97	13.46	457.24
1	24.75	17.63	436.34
0	27.41	13.99	383.47
1	21.3	12.26	261.14
0	27.6	10.58	292.01
1	18.24	17.65	321.94
0	21.1	18.13	382.54
0	17.54	15.49	271.69
0	28.92	15.8	456.94
0	23.5	19.43	456.61
1	19.56	14.18	277.36
0	21.16	14.13	298.99
1	19.05	14.5	276.23
2	22.94	13.89	318.64
2	25.68	14.39	369.54
0	28.08	10.32	289.79

0	26.45	11.72	309.99
0	21.88	16.4	358.83
0	27.29	13.39	365.41
0	23.39	20.17	471.78
1	25.51	15.78	402.55
0	31.82	12.43	395.52
0	33	10.42	343.86
0	17.77	17.08	303.51
1	17.81	15.62	278.19

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Weight (g)	Length (mm)	Width (mm)	Surface Area (mm)
543	240.3	95.11	22854.93
28	72.38	50.49	3654.47
45	118.93	41.12	4890.40
44	86.06	58.15	5004.39
3	28.37	27.34	775.64
4	28.63	17.48	500.45
4	26.4	20.99	554.14
0	26.93	8.85	238.33
0	17.91	8.8	157.61
0	18.16	10.48	190.32
0	14.59	10.04	146.48
0	15.8	11.84	187.07
0	26.1	7.72	201.49
0	12.5	10.22	127.75
0	15.85	6.8	107.78
0	15.16	8.84	134.01
0	15.54	5.73	89.04
0	12.85	5.84	75.04
0	14.51	6.27	90.98
0	8	5.88	47.04
0	6.08	4.81	29.24
0	10.08	6.16	62.09
0	13.42	4.36	58.51
0	7.52	6.45	48.50
14	59.1	26.44	1562.60
3	38.12	17.93	683.49
6	58.87	15.37	904.83
10	46.69	32.71	1527.23
4	46.13	20.31	936.90
4	49.16	15.19	746.74
13	57.24	45.22	2588.39
4	36.84	21.02	774.38
26	85.01	46.95	3991.22
4	40.05	19.39	776.57
7	46.26	22.65	1047.79
13	52.69	35.03	1845.73
3	36.08	15.47	558.16
8	34.32	32.96	1131.19
2	31.92	17.03	543.60
2	28.77	13.17	378.90
0	16.45	11.57	190.33
0	16.59	9.25	153.46
1	30.6	14.01	428.71
7	56.6	21.15	1197.09
9	60.37	23.94	1445.26
12	66.27	32.8	2173.66
13	59.02	31.55	1862.08
3	38.67	15.11	584.30
6	45.07	16.66	750.87
1	22.31	20.26	452.00
1	27.58	9.86	271.94
0	16.02	13.03	208.74
0	19.18	10.95	210.02
0	22.54	9.19	207.14
0	14.85	6.55	97.27
2	34.4	11.58	398.35
3	28.27	21.19	599.04
0	8.44	6.48	54.69
2	21.59	15.13	326.66
9	43.38	25.37	1100.55
4	36.72	14.75	541.62
3	46.06	18.99	874.68
7	40.82	29.34	1197.66
12	56.55	34.03	1924.40
4	33.85	14.83	502.00
3	32.36	19.83	641.70
9	40.85	24.4	996.74
0	22.83	19.65	448.61
0	30.15	10.82	326.22
2	34.51	17.43	601.51
0	17.68	13.43	237.44
0	22.65	14.72	333.41
6	35.32	26.36	931.04
0	19.55	13.18	257.67
4	43.1	23.02	992.16
3	28.26	21.35	603.35
36	63.41	44.14	2798.92
24	77.08	35.73	2754.07
17	58	34.19	1983.02
5	40.46	26.85	1086.35
0	32.7	20.65	675.26
0	27.76	20.68	574.08
0	17.89	10.16	181.76
2	30.34	14	424.76
4	36.68	14.82	543.60
6	43.55	33.08	1440.63
3	42.53	15.93	677.50
2	18.95	9.97	188.93
0	20.22	13.08	264.48
0	16.81	8.19	137.67
0	18.16	15.57	282.75
4	45.2	29.48	1332.50
10	59.75	20.11	1201.57
2	33.32	17.68	589.10
1	26	11.64	302.64
0	18.68	9.97	186.24
0	14.03	5.69	79.83

0	13.91	5.72	79.57
0	12.89	5.73	73.86
0	18.7	7.46	139.50
0	16.06	11.14	178.91
0	17.11	11.07	189.41
0	17.39	8.34	145.03
0	21.24	7.22	153.35
12	42.84	40.98	1755.58
8	52.36	37.64	1970.83
23	56.24	35.75	2010.58
8	55.24	17.86	986.59
4	34.06	22.07	751.70
0	25.31	7.69	194.63
0	10.93	6.04	66.02
2	17.42	12.89	224.54
4	38.15	17.8	679.07
10	43.93	33.15	1456.28
4	41.01	17.32	710.29
0	21.85	14.06	307.21
3	28.03	14.38	403.07
1	22.7	17.63	400.20
3	29.55	18.64	550.81
0	30.55	8.53	260.59
0	23.08	12.75	294.27
0	24.86	14.95	371.66
0	14.04	13.69	192.21
0	17.05	11.15	190.11
0	23.31	11.26	262.47
0	22.08	12.7	280.42
0	18.06	10.18	183.85
0	19.74	6.62	130.68
0	20.42	7.74	158.05
0	12.17	7.21	87.75
0	13.42	9.39	126.01
0	11.1	6.24	69.26
0	14.31	8.83	126.36
0	12.95	4.66	60.35
0	18.36	4.7	86.29
0	13.08	6.46	84.50
0	13.21	5.71	75.43
0	10.17	5.9	60.00
0	13.93	5.43	75.64
3	44.9	16.58	744.44
11	46.43	28.85	1339.51
2	31.52	16.89	532.37
3	22.39	18.02	403.47
2	24.01	11.13	267.23
3	43.05	14.44	621.64
4	39.34	18.7	735.66
11	53.95	18.62	1004.55
18	56.6	36.59	2070.99
12	40.18	31.76	1276.12
7	44.1	29.08	1282.43
4	49.27	17.45	859.76
1	31.21	15.74	491.25
11	49.77	34.44	1714.08
5	37.14	23.36	867.59

3	37.57	16.2	608.63
3	21.6	18.15	392.04
0	29.76	8.3	247.01
0	29.66	8.92	264.57
0	16.08	11.16	179.45
29	36.41	31.29	1139.27
4	52.15	20.04	1045.09
3	26.44	19.88	525.63
2	26.67	14.11	376.31
0	18.8	16.01	300.99
0	15.66	13	203.58
0	27.5	10.37	285.18
0	19.62	7.27	142.64
2	31.64	18.01	569.84
13	52.56	37.84	1988.87
11	43.14	33.31	1436.99
4	28.2	21.01	592.48
3	33.51	18.73	627.64
2	30.07	18.47	555.39
7	35.64	22.31	795.13
2	28.92	16.97	490.77
10	43.09	33.63	1449.12
5	49.13	20.71	1017.48
5	30.92	21.41	662.00
4	37.53	18.86	707.82
2	20	15.63	312.60
1	32.05	11.76	376.91
2	25.39	13.02	330.58
0	22.4	16.21	363.10
0	19.13	9.24	176.76
7	39.18	21.78	853.34
3	32.64	19.12	624.08
7	36.2	20.53	743.19
3	32.33	25.3	817.95
3	23.45	18.72	438.98
0	20.57	13.81	284.07
0	17.62	16.95	298.66
0	21.64	12.45	269.42
0	26.21	11.64	305.08
0	17.78	12.6	224.03
0	24.62	8.86	218.13
0	13.96	10.94	152.72
0	19.29	9.3	179.40
0	20.24	10.86	219.81
0	16.83	11.2	188.50
0	14.36	5.76	82.71
0	12.34	5.16	63.67
4	47.07	12.92	608.14
4	33.78	21.84	737.76
3	46.39	16.81	779.82
4	24.27	21.18	514.04
5	32.65	20.63	673.57
0	23.1	15.6	360.36
0	19.69	17.33	341.23
0	21.3	14.09	300.12
0	22.93	9.57	219.44
0	15	14.19	212.85

0	9.53	8.18	77.96
13	44.3	27.96	1238.63
4	33	25.54	842.82
7	31.63	18.84	595.91
3	21.93	15.84	347.37
2	24.11	23.34	562.73
3	29.59	16.75	495.63
2	18.24	14.04	256.09
1	23.5	10.25	240.88
0	16.92	13.05	220.81
0	22.91	14.18	324.86
5	47.64	17.12	815.60
7	41.06	19.7	808.88
4	40.49	18.31	741.37
0	20.08	15.62	313.65
0	28.16	13.98	393.68
0	22.14	12.91	285.83
0	19.38	13.36	258.92
0	21.14	10.52	222.39
1	26.56	8.81	233.99
0	17.89	12.02	215.04
1	19.12	13.1	250.47
0	15.31	10.29	157.54
0	24.66	6.68	164.73
0	22.65	7.91	179.16
0	12.2	8.24	100.53
0	14.97	7.36	110.18
0	18.06	7.57	136.71
0	18.08	5.88	106.31
0	13.89	9.43	130.98
0	10.97	8.79	96.43
0	11.33	6.7	75.91
0	11.86	6.72	79.70
0	14.18	6.92	98.13
0	15.85	5.98	94.78
0	11.8	6.92	81.66
0	8.3	5.52	45.82
0	6.81	6.17	42.02
0	11.89	4.03	47.92
0	9.15	5.17	47.31
4	47.61	17.37	826.99
4	35.06	28.27	991.15
1	24.65	16.26	400.81
2	25.97	12.98	337.09
1	16.83	14.53	244.54
0	19.56	11.63	227.48
0	13.5	9.73	131.36
0	19.64	9.56	187.76
0	16.08	12.81	205.98
0	15.52	12.31	191.05
0	17.8	843	15005.40
0	13.28	8.28	109.96
0	13.01	6.55	85.22
0	12.65	5.34	67.55
0	8.6	4.68	40.25
0	10.69	4.1	43.83
17	74.82	32.51	2432.40

4	44.15	20.19	891.39
2	40.53	17.02	689.82
3	30.26	13.78	416.98
2	33.51	23.29	780.45
0	28.3	21.08	596.56
0	18.45	17.32	319.55
0	22.34	17.76	396.76
0	27.68	17.3	478.86
0	22.48	11.61	260.99
2	31.74	14.25	452.30
0	30.11	14.12	425.15
0	22.04	10.76	237.15
0	15.99	11.91	190.44
0	20.76	8.86	183.93
0	20.09	9.18	184.43
8	52.21	29.19	1524.01
4	26.06	25.22	657.23
2	27.17	19.5	529.82
1	32.96	10.65	351.02
0	16.85	13.04	219.72
0	43.48	6.59	286.53
0	17.58	11.76	206.74
0	23.67	9.76	231.02
0	18.57	7.92	147.07
0	16.94	10.15	171.94
7	48.48	35.76	1733.64
4	36.46	26.28	958.17
3	45.11	16.65	751.08
5	33.31	29.26	974.65
3	32.52	15.71	510.89
3	34.04	15.19	517.07
3	39.66	16.18	641.70
4	35.45	19.47	690.21
2	27.78	12.36	343.36
2	24.99	17.61	440.07
0	18.62	16.5	307.23
9	65.22	12.3	802.21
4	42.64	23.14	986.69
2	31.49	19.61	617.52
3	32.69	20.57	672.43
4	40.75	22.91	933.58
0	23.48	22.56	529.71
1	39.88	18.42	734.59
1	35.42	13.46	476.75
3	26.51	14.45	383.07
2	37.8	10.08	381.02
1	25.56	16.3	416.63
0	26.25	12.05	316.31
2	38.03	9.52	362.05
2	23.62	12.54	296.19
13	47.09	21.1	993.60
5	37.58	26.24	986.10
6	40.53	17.46	707.65
4	34.07	16.2	551.93
3	36.59	15.65	572.63
2	27.57	19.06	525.48
2	29.7	18.84	559.55

2	30.42	15.94	484.89
3	30.01	17.97	539.28
2	56.25	15.83	890.44
2	47.9	11.92	570.97
1	29.04	18.67	542.18
1	29.14	13.43	391.35
0	27.07	16.14	436.91
0	27.26	16.5	449.79
11	72.75	22.53	1639.06
15	67.27	21.14	1422.09
3	32.31	17.99	581.26
2	31.49	22.05	694.35
4	38.59	26.06	1005.66
2	36.27	18.64	676.07
0	22.34	10.03	224.07
7	38.51	27.96	1076.74
12	43.31	33.67	1458.25
4	59.84	18.49	1106.44
3	28.56	19.28	550.64
2	21.76	13.69	297.89
0	27.8	14.13	392.81
0	29.81	12.45	371.13
0	28.89	13.38	386.55
0	30.52	10.17	310.39
0	21.14	12.64	267.21
2	16.22	15.63	253.52
0	21.76	17.2	374.27
0	24.65	13.56	334.25
0	13.4	12.89	172.73
0	21.08	13.02	274.46
0	25.05	8.56	214.43
5	40.58	19.74	801.05
49	81.02	44.58	3611.87
15	51.79	30.32	1570.27
14	54.04	26.48	1430.98
14	54.96	27.69	1521.84
10	48.57	30.23	1468.27
6	38.34	24.71	947.38
7	44.01	17	748.17
5	44.56	21.18	943.78
3	31.82	23.47	746.82
2	29.48	18.54	546.56
0	17.73	9.13	161.87
0	25.41	11.34	288.15
0	13.27	9.97	132.30
0	18.66	7.36	137.34
0	19.56	5.59	109.34
0	15.21	7.62	115.90
0	16.25	10.33	167.86
0	18.56	7.16	132.89
0	17.66	6.24	110.20
0	13.69	8.15	111.57
0	12.79	9.25	118.31
0	12.69	7.06	89.59
0	11.47	6.22	71.34
0	8.37	7.21	60.35
0	11.18	5.87	65.63

0	9.28	4.65	43.15
0	10.35	4.48	46.37
0	6.82	5.13	34.99
0	6.22	4.98	30.98
36	73.6	54.03	3976.61
9	48.16	22.81	1098.53
5	41.06	29.04	1192.38
3	32.69	18.12	592.34
3	36.94	13.83	510.88
1	36.66	20.43	748.96
0	23.34	17.26	402.85
0	10.34	6.47	66.90
0	19.85	6.11	121.28
3	53.06	11.02	584.72
4	37.37	22.46	839.33
1	18.6	17.74	329.96
2	26.3	17.58	462.35
0	25.45	16.81	427.81
3	45.4	16.82	763.63
0	18.7	12.6	235.62
0	22.39	14.36	321.52
0	21.07	15.11	318.37
0	20.19	17.14	346.06
0	23.62	12.33	291.23
0	23.85	10.62	253.29
0	23.21	8.8	204.25
0	15.21	10.24	155.75
0	19.24	12.14	233.57
0	17.29	10.73	185.52
0	16.57	8.53	141.34
0	11.34	10	113.40
12	58.07	23.8	1382.07
3	46.76	17.82	833.26
3	39.49	13.49	532.72
2	26.8	24.39	653.65
1	19.53	18.07	352.91
0	22.34	16.4	366.38
0	37	13.46	498.02
0	16.97	9.99	169.53
0	13.36	8.28	110.62
4	23.5	21.53	505.96
3	25.42	17.09	434.43
4	28.11	17.78	499.80
3	31.14	17.08	531.87
3	35.78	8.87	317.37
4	30.56	28.29	864.54
2	23.67	18.55	439.08
0	32.31	14.71	475.28
0	27.43	10.5	288.02
0	20.51	9.19	188.49
0	15.14	11.99	181.53
0	16.08	15.53	249.72
0	13.4	9.21	123.41
17	56.16	35.63	2000.98
2	32.35	19.48	630.18
4	35.77	13.04	466.44
4	32.25	18.57	598.88

2	26.54	14.11	374.48
2	22.36	19.85	443.85
0	23.32	19.37	451.71
0	28.25	14.59	412.17
0	19.39	11.84	229.58
5	35.06	18.49	648.26
4	37.81	26.67	1008.39
3	37.77	14.51	548.04
2	21.57	18.66	402.50
1	30.04	16.65	500.17
3	24.58	23.35	573.94
0	25.09	18.65	467.93
0	12.08	9.26	111.86
0	21.03	13.21	277.81
0	11.74	11.04	129.61
0	15.36	8.4	129.02
0	16.61	8.28	137.53
0	11.67	8.32	97.09
0	14.16	9.75	138.06
0	15.82	8.54	135.10
0	17.8	8.18	145.60
0	13.56	6.63	89.90
0	14.17	3.54	50.16
0	15.5	4	62.00
0	9.43	5.63	53.09
0	10.62	4.36	46.30
4	24.72	23.78	587.84
5	48.15	18.17	874.89
2	27.48	24.13	663.09
2	22.54	19.62	442.23
3	26.2	20.38	533.96
11	60.62	30.34	1839.21
9	42.96	38.79	1666.42
10	59.21	21.49	1272.42
17	40.22	39.56	1591.10
7	49.46	28.93	1430.88
8	47.62	26.2	1247.64
50	84.5	48.49	4097.41
42	80.31	67.39	5412.09
7	54.33	29.1	1581.00
7	35.5	29.09	1032.70
9	49.62	25.86	1283.17
13	61.9	30.78	1905.28
7	30.57	28.18	861.46
3	25.67	22.56	579.12
3	27.24	22.2	604.73
5	38.51	23.94	921.93
9	66.1	24.29	1605.57
2	38.47	16.27	625.91
12	62.91	26	1635.66
7	41.13	24.5	1007.69
13	50.04	33.67	1684.85
77	83.51	76.74	6408.56
7	48.52	25.44	1234.35
12	49.09	35.06	1721.10
11	48.72	35.33	1721.28
3	38.37	19.49	747.83

5	23.87	19.43	463.79
4	37.58	20.86	783.92
5	39.85	33.78	1346.13
2	27.44	22.9	628.38
2	27.15	18.29	496.57
3	30.84	22.86	705.00
4	27.68	16.62	460.04
5	38	24.61	935.18
2	28.43	14.7	417.92
2	29.82	21.34	636.36
1	36.02	18.39	662.41
2	31.12	16.93	526.86
2	41.22	15.71	647.57
4	36.73	18.28	671.42
3	29.79	24.27	723.00
2	35.99	18.37	661.14
6	40.72	25.36	1032.66
2	27.53	19.06	524.72
3	31.56	21.88	690.53
8	39.95	33.1	1322.35
1	30.17	17.04	514.10
5	42.22	15.89	670.88
5	39.22	18.63	730.67
2	28.97	19.13	554.20
4	29.72	23.46	697.23
3	26.39	19.37	511.17
8	51.52	28.11	1448.23
4	27.67	26.71	739.07
4	53.02	23.52	1247.03
7	45.34	29.33	1329.82
2	38.58	21.27	820.60
4	30.85	25.81	796.24
1	21.86	12.55	274.34
2	38.78	14.53	563.47
19	71.37	37.55	2679.94
2	35.09	19.87	697.24
4	26.49	21.61	572.45
3	31.9	21.12	673.73
2	29.11	20.52	597.34
2	25.66	18.34	470.60
3	27.26	22.05	601.08
1	27.23	21.02	572.37
4	29.06	24.02	698.02
2	30.54	28.33	865.20
1	29.23	10.46	305.75
33	84.8	42.21	3579.41
6	48.03	20.13	966.84
6	47.67	21.72	1035.39
2	33.95	16.93	574.77
4	44.99	20.13	905.65
3	31.62	23.43	740.86
0	35.08	12	420.96
2	23.55	21.64	509.62
10	40.32	36.31	1464.02
18	70.64	37.31	2635.58
11	73.55	24.94	1834.34
44	72.82	51.03	3716.00

16	59.75	31.86	1903.64
95	112.47	39.04	4390.83
24	71.96	45.95	3306.56
23	63.18	53.85	3402.24
12	48.16	29.46	1418.79
10	60.23	40.08	2414.02
4	45.11	24.45	1102.94
6	39.61	26.1	1033.82
10	53.29	33.45	1782.55
6	50.64	24.46	1238.65
15	47.5	26.96	1280.60
5	50.67	20.73	1050.39
5	50.98	22.36	1139.91
3	36.27	17.32	628.20
6	31.9	31.03	989.86
27	67.96	45.75	3109.17
4	36.26	20.27	734.99
4	34.54	18.99	655.91
25	59.4	40.37	2397.98
73	83.78	58.47	4898.62
8	45.45	29.92	1359.86
5	35.21	29.24	1029.54
44	75.55	61.43	4641.04
143	169	58.51	9888.19
20	62.02	49.71	3083.01
11	44.87	41.23	1849.99
7	43.98	20.54	903.35
2	34.36	16.34	561.44
5	47.3	28.06	1327.24
8	58.47	18.8	1099.24
2	29.74	27.68	823.20
3	31.67	19.91	630.55
4	34.86	26.18	912.63
3	27.56	21.4	589.78
7	49.78	30.69	1527.75
26	71.35	41.22	2941.05
6	53.21	28.44	1513.29
5	43.83	30.39	1331.99
9	59.87	29.94	1792.51
4	35.54	19.77	702.63
2	43.71	18.29	799.46
11	42.82	31.64	1354.82
13	66.33	20.49	1359.10
5	49.26	20.75	1022.15
4	41.22	23.54	970.32
3	27	16.67	450.09
5	51.34	21.1	1083.27
9	35.9	29.99	1076.64
10	59.87	27.29	1633.85
3	35.06	18.47	647.56
10	33.28	32.82	1092.25
6	30.73	30.48	936.65
4	54.95	17.02	935.25
20	76.59	28.25	2163.67
2	30.35	22.91	695.32
7	41.18	32.76	1349.06
3	36.31	17.53	636.51

0	24.19	20.85	504.36
4	33.38	28.84	962.68
5	57.96	23.16	1342.35
7	45.13	25.38	1145.40
4	39.5	18.05	712.98
3	36.48	18.56	677.07
3	32.55	23.41	762.00
4	42.3	17.1	723.33
2	21.28	21.77	463.27
6	30.09	23.24	699.29
7	36.98	25.24	933.38
6	29.86	24.56	733.36
15	75.57	23.04	1741.13
31	72.28	44.1	3187.55
33	56.99	44.57	2540.04
6	55.42	22	1219.24
14	56.92	50.9	2897.23
11	64.19	30.22	1939.82
11	51.82	29.87	1547.86
8	56.62	14.97	847.60
8	54.21	24.42	1323.81
14	54.83	25.45	1395.42
4	41.27	21.89	903.40
18	77.45	38.76	3001.96
8	53.43	26.4	1410.55
7	54.52	21.29	1160.73
16	66.99	29.24	1958.79
7	47.16	25.87	1220.03
5	38.19	30.75	1174.34
7	55.51	28.71	1593.69
13	39.66	27.63	1095.81
6	40.14	25.61	1027.99
8	52.51	35.36	1856.75
2	26.19	23.78	622.80
3	22.43	20.17	452.41
1	28.18	18.7	526.97
4	36.06	18.25	658.10
6	39.25	21.67	850.55
5	33.26	25.66	853.45
3	33.32	20.79	692.72
5	35.77	30.89	1104.94
5	41.28	20.49	845.83
7	44.66	17.23	769.49
2	30.36	25.06	760.82
2	27.18	19.67	534.63
1	33.79	21.37	722.09
2	28.02	20.94	586.74
3	29.31	20.01	586.49
2	27.63	20.75	573.32
2	25.78	11.93	307.56
2	30.33	20.11	609.94
7	38.1	35.41	1349.12
44	114.69	37.4	4289.41
29	74.95	46.09	3454.45
22	51.89	41.05	2130.08
18	53.45	38.01	2031.63
5	36.97	32.95	1218.16

16	62.61	31.53	1974.09
12	40.61	27.31	1109.06
7	49.76	25.53	1270.37
10	32.01	31.34	1003.19
4	38.23	21.98	840.30
5	46.88	21.1	989.17
11	51.25	31.82	1630.78
4	43.64	26.69	1164.75
4	40.97	15.77	646.10
4	33.14	31.94	1058.49
4	31.49	28.31	891.48
3	29.14	22.24	648.07
1	26.48	17.37	459.96
5	33.68	22.35	752.75
3	38.97	18.29	712.76
9	42.16	31.21	1315.81
10	46.48	29.8	1385.10
25	68.13	42.29	2881.22
13	58.8	33.15	1949.22
4	37.95	24.02	911.56
5	36.1	22.38	807.92
3	30.14	24.58	740.84
5	31.5	24.32	766.08
4	29.52	21.28	628.19
5	40.79	18.55	756.65
4	40.54	20.77	842.02
4	34.43	20.31	699.27
16	52.42	43.31	2270.31
8	38.02	24.06	914.76
6	41.49	19.58	812.37
4	39.09	24.57	960.44
3	40.01	20.76	830.61
5	52.66	16.58	873.10
3	44.13	16.59	732.12
4	38.58	26.79	1033.56
8	34.29	32.28	1106.88
16	49.2	39.15	1926.18
5	42.06	19.5	820.17
9	50.05	30.54	1528.53
5	42.8	23.57	1008.80
4	35.42	15.55	550.78
4	56.79	14.95	849.01
11	49.34	32.87	1621.81
12	43.86	34.63	1518.87
3	28.34	24.98	707.93
3	31.95	17.96	573.82
4	63.16	19.71	1244.88
1	29.63	18.53	549.04
1	28.95	18.54	536.73
3	37.3	19.23	717.28
1	21.69	18.68	405.17
5	34.28	22.63	775.76
4	45.79	22.53	1031.65
3	42.62	19.22	819.16
3	39.22	13.57	532.22
4	34.21	16.22	554.89
7	38.42	23.24	892.88

4	44.03	18.15	799.14
0	34.51	17.09	589.78
2	37.62	21.58	811.84
1	38.81	19.96	774.65
4	37.46	20.89	782.54
4	40.25	16.45	662.11
4	34.09	18.98	647.03
2	27.43	20.98	575.48
3	34.84	17.94	625.03
3	29.64	24.74	733.29
7	61.25	29.1	1782.38
15	61.58	39.21	2414.55
13	63.92	44.42	2839.33
26	69.33	46.53	3225.92
33	76.84	43.63	3352.53
71	123.34	54.43	6713.40
49	75.93	65.7	4988.60
106	101.07	83.42	8431.26
163	144.64	62.04	8973.47
105	138.5	57.58	7974.83
67	150.29	78.34	11773.72
197	136.32	111.32	15175.14
3	34.07	24.49	834.37
2	33.42	22.66	757.30
2	23.72	19.56	463.96
2	35.45	23.04	816.77
2	34.43	16.4	564.65
1	25.91	15.25	395.13
1	39.9	12.85	512.72
3	30.86	19.87	613.19
2	25.5	17.37	442.94
4	29.87	21.83	652.06
3	28.51	19.79	564.21
3	53.15	15.95	847.74
5	33	20.92	690.36
2	32.7	16.69	545.76
1	29.83	16.16	482.05
2	26.24	17.83	467.86
1	26.99	16.71	451.00
2	27.83	15.79	439.44
2	30.72	19.35	594.43
2	28.71	17.73	509.03
2	22.13	15.49	342.79
2	24.68	13.87	342.31
3	25.61	19.09	488.89
1	21.37	15.82	338.07
4	20.77	19.4	402.94
2	29.69	12.74	378.25
2	25.68	20.69	531.32
2	27.43	17.23	472.62
1	24.76	19.28	477.37
1	22.14	17.69	391.66
3	28.71	18.49	530.85
2	20.59	18.18	374.33
3	39.65	16.13	639.55
0	25.31	21.5	544.17
2	36.8	12.85	472.88

1	23.45	15.8	370.51
3	25.13	15.22	382.48
4	17.89	14.37	257.08
2	28.9	21.04	608.06
3	27.93	21.79	608.59
0	32.06	11.96	383.44
0	23.12	14.82	342.64
2	29.74	16.98	504.99
2	28.57	15.37	439.12
3	23.03	14.37	330.94
2	33.62	13.2	443.78
0	25.06	17.74	444.56
0	25.03	11.61	290.60
2	30.7	14.49	444.84
1	24.5	18.07	442.72
2	24.73	19.66	486.19
3	30.48	16.34	498.04
3	31.55	17.64	556.54
18	45.08	43.83	1975.86
1	26.37	18.72	493.65
3	24.24	16.99	411.84
3	33.62	15.75	529.52
3	32.11	16.42	527.25
16	32.98	24.58	810.65
5	22.59	21.26	480.26
4	28.82	20.11	579.57
4	28.74	25.37	729.13
4	27.23	19.98	544.06
3	36.96	19.21	710.00
3	31.47	16.94	533.10
1	21.74	19.08	414.80
3	49.99	16.03	801.34
4	29.32	26.97	790.76
4	31.96	20.4	651.98
0	28.26	17.46	493.42
2	25.79	13.96	360.03
1	25.01	17.62	440.68
3	17.77	14.71	261.40
3	38.53	14.32	551.75
3	41.99	15.17	636.99
2	24.73	22.59	558.65
0	38.83	10.95	425.19
3	17.03	15.47	263.45
2	28.38	16.31	462.88
1	20.57	14.64	301.14
2	23.92	19.19	459.02
2	28.87	18.09	522.26
0	19.13	14.7	281.21
2	32.08	16.52	529.96
2	25.58	14.63	374.24
1	32.36	11.62	376.02
2	25.13	16.01	402.33
1	24.8	13.64	338.27
3	32.82	17.28	567.13
4	40.2	20.58	827.32
1	32.24	15.58	502.30
1	34.41	12.95	445.61

2	22.1	18.29	404.21
2	23.03	18.85	434.12
4	18.54	15.69	290.89
2	28.72	15.55	446.60
3	29.93	18.96	567.47
0	26.54	16.92	449.06
2	28.39	13.99	397.18
2	25.8	14.55	375.39
2	28.56	19.06	544.35
2	21.45	20.75	445.09
3	44.16	17.71	782.07
1	29.84	15.39	459.24
0	26.82	22.23	596.21
1	26.86	18.09	485.90
1	35.21	13.4	471.81
1	36.87	12.16	448.34
0	26.88	21.77	585.18
3	32.44	18.72	607.28
3	27.91	16.4	457.72
1	32.27	14.96	482.76
3	37.14	18.22	676.69
2	33.64	10.34	347.84
3	38.58	13.03	502.70
1	26.08	11.42	297.83
0	27.41	14.04	384.84
1	31.78	14.76	469.07
2	28.72	15.3	439.42
1	28.7	12.84	368.51
1	29.84	13.84	412.99
2	22.3	16.93	377.54
0	25.67	13.45	345.26
1	25.54	15.44	394.34
0	22.87	20.32	464.72
2	29.74	15.08	448.48
1	26.47	12.44	329.29
1	27.6	19.88	548.69
2	27.83	18.32	509.85
1	27.98	18.05	505.04
1	26.15	14.21	371.59
2	41.47	15.71	651.49
1	23.33	13.86	323.35
2	31.41	14.67	460.78
0	36.79	12.47	458.77
1	25.98	17.62	457.77
2	28.55	16.31	465.65
0	23.82	18.42	438.76
1	32.32	17.87	577.56
3	26.42	18.16	479.79
3	26.61	20.01	532.47
0	36.54	12.2	445.79
1	19.41	18.25	354.23
1	30.23	17.4	526.00
2	27.21	19.97	543.38
2	29.41	15.27	449.09
0	18.63	17.02	317.08
2	26.24	13.46	353.19
2	26.53	15.78	418.64

2	35.58	12	426.96
0	20.16	15.14	305.22
0	21.71	12.72	276.15
0	23.23	17.26	400.95

Welsh Samples

Weight (g)	Length (mm)	Width (mm)	Surface Area (mm)
9	52.99	36.16	1916.12
12	87.39	17.29	1510.97
7	40.34	25.29	1020.20
9	51.49	19.12	984.49
6	47.15	24.97	1177.34
7	37.77	20.75	783.73
8	37.13	27.42	1018.10
4	31.06	23.66	734.88
4	35.16	13.12	461.30
4	33.32	14.98	499.13
4	33.19	23.06	765.36
3	51.14	20.53	1049.90
3	24.7	18.13	447.81
2	38.19	14.25	544.21
3	31.5	19.17	603.86
0	27.6	16.09	444.08
0	26.37	12.8	337.54
2	26.58	17.9	475.78
5	48.03	19.55	938.99
0	36.8	10.26	377.57
4	55.11	14.78	814.53
7	38.43	34.73	1334.67
10	58.19	37.69	2193.18
7	43.66	37.08	1618.91
6	47.93	21.14	1013.24
3	40.1	14.32	574.23
3	39.33	24.52	964.37
0	25.45	11.42	290.64
9	57.32	18.63	1067.87
4	60.73	17.7	1074.92
5	53.86	13.31	716.88
4	40.82	15.45	630.67
4	47.9	24.38	1167.80
3	38.53	25.74	991.76
4	44.63	17.21	768.08
4	35.54	22.8	810.31
2	45.43	13.09	594.68
3	45.28	13.97	632.56
2	27.69	15.91	440.55
1	40.56	10.23	414.93
0	30.8	15.48	476.78
0	27.14	14.23	386.20
0	27.3	16.97	463.28
0	23.95	16	383.20
0	20.54	9.3	191.02
0	25.66	12.78	327.93
0	31.38	14.07	441.52
6	34.52	20.06	692.47
1	31.23	13.28	414.73
4	35.1	21.79	764.83
2	42.18	18.57	783.28
4	53.81	14.6	785.63
4	32.15	18.02	579.34
2	47.94	16.06	769.92
1	38.26	21.57	825.27
1	41.72	15.88	662.51
2	39.79	18.35	730.15
1	34.93	13.04	455.49
0	20.47	14.84	303.77
0	30.1	15.66	471.37
0	35.04	15.84	555.03
2	22.63	14.03	317.50
0	27.56	14.54	400.72
0	30.92	10.42	322.19
0	20.5	11.86	243.13
0	29.09	6.62	192.58
4	61.07	17.23	1052.24
7	64.16	24.47	1570.00
5	42.71	24.8	1059.21
10	70.33	21.01	1477.63
7	49.05	18.67	915.76
4	46.8	15.38	719.78
4	37.74	18.63	703.10
2	27.96	18.55	518.66
2	39.24	17.69	694.16
2	31.59	14.27	450.79
1	35.69	16.1	574.61
2	35.64	16.21	577.72
0	29.4	10.95	321.93
0	28.39	13.92	395.19
8	54.99	23.48	1291.17
7	46.07	24.34	1121.34
3	36.85	16.15	595.13
3	44.79	13.7	613.62
2	40.2	10.49	421.70
2	31.99	19.27	616.45
1	32.35	13.5	436.73
0	32.66	16.96	553.91
0	39.27	13.69	537.61
1	29.99	13.88	416.26
0	20.93	15.13	316.67
0	25.94	9.41	244.10
0	23.44	18.37	430.59
0	21.07	7.49	157.81
0	23.24	18.3	425.29
0	23.36	10.75	251.12
0	28.18	10.14	285.75
0	15.9	13.04	207.34
0	21.92	11.13	243.97
0	16.81	6.68	112.29
0	23.37	8.29	193.74
0	22.09	7.97	176.06

0	18.75	11.87	222.56
0	21.4	8.36	178.90
0	15.61	8.8	137.37
0	17.82	13.2	235.22
0	15.29	7.81	119.41
0	13.35	9.04	120.68
0	19.14	7.13	136.47
0	16.9	5.54	93.63
0	19.24	5.92	113.90
0	14.72	7.89	116.14
0	14.43	10.61	153.10
0	18	5.81	104.58
0	20.17	3.81	76.85
0	10.29	9.44	97.14
0	16.4	8.41	137.92
0	17.26	6.21	107.18
3	33.42	18.9	631.64
6	68.51	20.32	1392.12
9	72.26	17.91	1294.18
6	41.12	19.14	787.04
5	40.93	29.52	1208.25
3	39.35	22.24	875.14
4	46.35	15.24	706.37
3	33.28	24.11	802.38
9	50.04	35.38	1770.42
6	52.33	20.35	1064.92
2	25.02	13.56	339.27
3	35.23	16.35	576.01
3	40.58	16.88	684.99
3	36.3	13.27	481.70
0	32.05	17.56	562.80
2	28.3	15.02	425.07
0	27.21	15.77	429.10
0	47.97	10.3	494.09
0	27.99	12.06	337.56
0	26.98	13.9	375.02
1	24.78	16.84	417.30
0	26.37	12.4	326.99
0	21.56	16.72	360.48
0	36.19	9.3	336.57
0	24.13	14.77	356.40
0	18.52	11.83	219.09
0	25.19	10.46	263.49
0	21.99	11.58	254.64
0	22.03	12.84	282.87
0	28.72	9.07	260.49
0	31.57	14.24	449.56
0	19.96	9.96	198.80
0	17.32	10.91	188.96
0	14.62	10.46	152.93
0	12.42	9.05	112.40
0	19.78	9.19	181.78
0	18.38	9.83	180.68
0	10.56	8.9	93.98
0	19.99	11.24	224.69
0	17.83	10.21	182.04
0	16.82	10.25	172.41

0	15.6	8.75	136.50
0	18.26	5.9	107.73
0	16.46	8.17	134.48
0	15.94	9.18	146.33
0	24.3	7.12	173.02
0	23.7	5.83	138.17
0	17.01	8.02	136.42
0	12.74	5.62	71.60
0	18.09	5.37	97.14
0	11.31	8.95	101.22
0	13.54	5.85	79.21
0	13.4	6.1	81.74
0	14.88	4.66	69.34
0	14.57	4.05	59.01
0	10.41	7.83	81.51
0	9.8	6.86	67.23
0	10.68	7.35	78.50
0	15.13	6.93	104.85
2	28.64	19.17	549.03
4	39.88	20.21	805.97
1	24.41	16.39	400.08
2	26.89	21.56	579.75
2	39.92	10.94	436.72
2	30.5	20.8	634.40
1	23.52	9.16	215.44
0	28.56	17.72	506.08
2	30.29	19.09	578.24
0	22.68	11.93	270.57
1	24.95	15.98	398.70
0	24.92	17.06	425.14
0	23.9	15.84	378.58
0	20.15	7.01	141.25
0	21.29	11.75	250.16
0	19.16	12.81	245.44
0	24.73	15.09	373.18
0	20.13	9.4	189.22
0	17.5	12.77	223.48
0	18.51	11.92	220.64
0	15.32	14.89	228.11
0	20.99	16.78	352.21
0	16.05	12.08	193.88
0	26.9	10.22	274.92
0	25.6	11.44	292.86
0	18.33	10.52	192.83
0	20.7	10.68	221.08
0	24.57	10.69	262.65
0	15.37	13.64	209.65
0	24.66	8.18	201.72
0	16.32	11.2	182.78
0	24.36	9.46	230.45
0	17.33	12.32	213.51
0	13.14	12.53	164.64
0	19.67	8.86	174.28
0	21.55	7.05	151.93
0	21.47	11	236.17
0	16.19	8.19	132.60
0	15.47	9.57	148.05

0	18.65	9.91	184.82
2	31.81	6.05	192.45
5	55.42	11.66	646.20
10	66.85	22.12	1478.72
24	48.42	36.47	1765.88
18	55.55	27.08	1504.29
20	68.52	22.98	1574.59
10	47.55	18.04	857.80
7	43.48	20.24	880.04
6	39.63	16.67	660.63
8	59.06	22.08	1304.04
5	42.66	24.89	1061.81
7	56.16	15.95	895.75
15	34.18	23.86	815.53
7	50.4	20.78	1047.31
2	45.79	10.38	475.30
4	45.1	12.77	575.93
1	41.71	8.37	349.11
2	30.31	14.02	424.95
2	35.39	11.56	409.11
0	30.58	6.84	209.17
0	30.05	5.76	173.09
2	29.65	9.73	288.49
11	46.75	22.2	1037.85
8	29.64	19.08	565.53
7	55.94	17.63	986.22
4	36.64	10.63	389.48
5	41.29	26.4	1090.06
8	55.64	23.85	1327.01
3	33.76	11.16	376.76
4	38.89	9.38	364.79
2	23.79	19.29	458.91
1	28.46	11.05	314.48
2	40.75	12.99	529.34
2	20.32	17.12	347.88
0	19.71	11.83	233.17
0	23.58	10.11	238.39
0	26.87	8.93	239.95
0	15.06	7.54	113.55
0	10.99	7.78	85.50
0	13.92	7.24	100.78
9	45.14	21.43	967.35
11	38.03	22.48	854.91
8	79	12.26	968.54
11	66.04	21.16	1397.41
13	67.03	29.52	1978.73
5	31.77	25.94	824.11
5	45.54	20.07	913.99
12	58.15	22.79	1325.24
3	25.01	15.35	383.90
5	29.49	20.73	611.33
5	34.97	23.3	814.80
2	22.31	21.33	475.87
3	66.78	10.27	685.83
2	20.63	11.59	239.10
2	36.01	8.88	319.77
2	43.49	10.64	462.73

1	40.13	11.71	469.92
1	35.86	9.4	337.08
1	26.91	14.78	397.73
2	30.31	9.52	288.55
1	26.47	11.37	300.96
0	16.31	9.73	158.70
7	40.23	24.11	969.95
18	39.33	30.42	1196.42
26	99.68	20.95	2088.30
14	41.7	34.89	1454.91
5	45.61	13.95	636.26
7	30.93	26.25	811.91
5	63.09	12.3	776.01
2	43.73	21.74	950.69
3	43.24	17.22	744.59
1	42.1	13.6	572.56
3	40.97	17.51	717.38
2	26.2	20.66	541.29
2	24.9	11.01	274.15
3	30.27	13.04	394.72
0	25.94	17.13	444.35
1	33.2	17.23	572.04
0	19.54	18.84	368.13
2	48.02	15	720.30
1	31.99	10.49	335.58
2	24.87	12.33	306.65
0	25.01	8.68	217.09
0	18.56	10.43	193.58
0	24.57	10.26	252.09
0	23.33	9.38	218.84
0	18.23	12.91	235.35
0	20.86	9.47	197.54
0	15.79	10.02	158.22
0	22.81	8.84	201.64
0	22.09	7.04	155.51
0	16.33	12.05	196.78
6	53.34	16.97	905.18
14	50.8	25.34	1287.27
3	56.54	13.75	777.43
5	51.79	20.44	1058.59
0	30.89	13.49	416.71
49	107.38	29.71	3190.26
4	33.91	21.46	727.71
9	64.27	15.34	985.90
2	25.18	17.59	442.92
4	56.81	10.34	587.42
4	46.26	16.59	767.45
4	37.9	21.03	797.04
1	32.55	14.81	482.07
4	57.79	11.41	659.38
2	47.04	14.66	689.61
3	47.45	13.49	640.10
2	24.32	9.96	242.23
2	31.56	11.8	372.41
2	31.97	11.02	352.31
2	23.33	7.86	183.37
0	15.27	9.38	143.23

0	20.65	7.88	162.72
0	23.21	10.54	244.63
0	17.4	6.96	121.10
6	33.29	21.5	715.74
3	38.96	11.52	448.82
4	42.28	12.21	516.24
2	47.23	15.88	750.01
2	59.13	10.28	607.86
3	33.68	15.3	515.30
3	28.77	21.43	616.54
2	25.3	10.88	275.26
3	42.61	12.2	519.84
1	36.47	9.96	363.24
3	32.05	15.98	512.16
2	34.06	10.47	356.61
1	28.5	13.3	379.05
0	21.27	15.68	333.51
1	23.31	16.57	386.25
4	37.48	16.14	604.93
5	34.04	23.27	792.11
5	19.53	17.18	335.53
12	43.85	27.72	1215.52
3	35.31	10.2	360.16
5	42.72	13.45	574.58
3	27.55	22.53	620.70
4	44.43	12.06	535.83
3	24.16	17.1	413.14
2	36.37	13.84	503.36
2	35.66	15.24	543.46
3	23.93	19.41	464.48
2	37.08	13.01	482.41
5	33.19	20.16	669.11
2	44.97	8.85	397.98
1	34.73	10.07	349.73
5	51.71	20.76	1073.50
2	16.87	15.68	264.52
2	38.23	14.9	569.63
3	36.78	15.04	553.17
1	22.62	15.56	351.97
3	31.27	14.94	467.17
2	29.08	13.6	395.49
2	32.61	14.55	474.48
2	28.51	20.17	575.05
1	28.55	13.74	392.28
1	27	13.44	362.88
3	38.1	12.55	478.16
1	26.44	13.69	361.96
3	24.72	15.11	373.52
2	29.56	12.8	378.37
2	27.7	13.82	382.81
1	38.47	11.58	445.48
0	31.38	12.19	382.52
1	28.25	11.5	324.88
3	49.48	13.43	664.52
2	38.46	13.71	527.29
1	31.27	10.82	338.34
2	37.93	12.71	482.09

2	31.77	12.06	383.15
0	26.78	11.9	318.68
0	21.59	9.92	214.17
0	15.94	15.26	243.24
1	27.56	13.53	372.89
1	26.11	15.21	397.13
0	27.57	11.92	328.63
2	37.58	10.98	412.63
0	15.44	7.09	109.47
0	21.48	13.85	297.50
0	32.29	7.54	243.47
0	23.99	13.96	334.90
3	33.62	11.82	397.39
3	36.35	14.86	540.16
1	30.5	15.03	458.42
2	31.88	16.69	532.08
1	26.08	10.31	268.88
1	21.66	12.76	276.38
0	22.13	9.84	217.76
0	21.91	10.63	232.90
1	16.67	12.58	209.71
0	30.07	11.56	347.61
0	30.84	11.23	346.33
1	29.67	9.94	294.92
0	21.1	8.9	187.79
0	22.61	8.72	197.16
0	18.94	13.25	250.96
0	24.46	9.22	225.52
1	29.34	12.17	357.07
1	25.14	14.98	376.60
1	26.91	14.89	400.69
0	23.47	14.2	333.27
1	32.8	9	295.20
1	31.08	10.02	311.42
1	22.25	16.51	367.35
0	15.46	10.35	160.01
0	27.65	7.61	210.42
0	23.67	7.82	185.10
2	25.75	13.44	346.08
2	24.2	10.96	265.23
0	30.43	11.6	352.99
0	28.9	8.41	243.05