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# **Approaching the mind of the builder**

**Analysis of the physical, structural and social constraints on  
the construction of the broch towers of Iron Age Scotland**

**John Barber**

**I, the undersigned John Barber (s1164769) declare that:**

- a) This thesis was composed by me
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John Barber



Date

05/10/2016

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# Preface

This study concerns broch towers, monuments of the Iron Age in Scotland, built from drystone, i.e. without clay, mortar or cement. Other monument types have been called 'brochs' but, and for the avoidance of doubt, this study concerns broch towers and where the term 'broch' is used in isolation it still refers to broch towers unless the contrary is specified. It concerns itself with the construction of broch towers and the technical and social constraints on that process. It does not greatly concern itself with artefacts found in, on or around brochs and neither does it concern itself with typologies of broch-like monuments, other than to show why these are dismissed as irrelevant to this study.

In dealing with the structures in and inwards always mean in the direction of the centre of the broch tower. Similarly, out and outwards means away from the centre of the tower. The abbreviations LHS and RHS mean left and right hand sides looking towards the centre, unless otherwise stated. Attributes within the broch are conventionally described in terms of a clockface with the number 6 aligned on the broch entrance, thus 12 is diametrically opposite the entrance and 9 is left of the centre, and so on. The levels within the broch are here termed ground, first storey, second storey, and so on. This breaks with the usual terminology of levels 1 to N, which confused my architectural colleagues.

The terminology used to further describe the broch can be seen in Figure 36 and has been used consistently, it is hoped. The organisation of the Case study texts has not proved amenable to complete standardisation because their differential preservation makes it hard to systematise their descriptions. Such consistency as could be imposed was imposed short of making the text unreadable. This study straddles architecture, with some architectural history and engineering on the one side and archaeology and prehistory on the other. This has required a high level of explanation of processes that readers from each area of expertise might need in areas strange to them but which they may query in respect of that which is well known to them; it has been a difficult balance to strike.

John Barber University of Edinburgh 2016

# Acknowledgements

The writer thanks his wife, Dr Anne Crone and his daughter Dr Katie Crone-Barber for their assistance especially during fieldwork and his son Darren for assistance with the management of images and the formatting of the thesis. He thanks them and the rest of his family for their limitless support and care during this project. He acknowledges with thanks the assistance of Una Lee and Ivor Davies during fieldwork in Lewis. Drs Andy Heald, Graeme Cavers, Dimitris Theodossopoulos and Jon Henderson who together with Paul Humphreys and the Caithness Archaeological Trust formed the Caithness Broch Project and the writer is grateful to them all for many hours of discussion on broch issues especially during the excavations of parts of five brochs. He is grateful to Dr Graeme Cavers and Gemma Hudson for the provision of the drawings images attributed to them and to Gemma Hudson for the rest of the line drawings and for their laser scan surveys of brochs only a fraction of which have been included. He thanks Kim Wilson for coding work for the database and Vicky Oleksy for preparing map images. He also acknowledges the consents of Alan Braby for the inclusion of a copy of his broch illustration (Figure 26) and to Martin Carruthers for his consent to include an image of his excavations at The Cairns broch (Figure 131). He is grateful to Historic Environment Scotland members; Richard Strachan for access to properties in care for survey purposes; to Alan Rutherford for Scheduled Monument Consent to conservation works at Clachtoll, and to their colleagues and advisors for help and advice. The work of Brian Smith (Shetland Archivist) on Clickhimin and Mousa has been inspiring and the writer is grateful to him for pre-publication access to his works. He thanks Caesare Nimerski for advice and guidance on Nuraghi. The writer's greatest academic debt is to Dr Dimitris Theodossopoulos, his first supervisor who, with Professor Iain Boyd White, his second supervisor, helped and guided his work at every stage. As a colleague, mentor and friend he has placed the writer deeply in his debt. In particular, the writer would like also to acknowledge the work of the Masters students, now Masters Graduates, who worked to Dimitris on aspects of the engineering of broch walls: Ian Thew; Alex Sutherland; Franziska Reutter; Jenny Gilbertson; and Katy Primavesi. To his PGR colleague Dimitra Ntzani he extends his warmest thanks for her intelligence and friendship and her unwillingness ever to provide or accept less than the very best. I am grateful also for the support of my PGR cohort for a student who was older than most of their parents; I thank them all for their kindness. My colleagues at AOC Archaeology Group have supported and encouraged me along the way and their help is gratefully acknowledged. Finally, I return to thank my wife Anne who suffered the boring and near terminal self obsession of the scholar in pursuit of understanding. If mine has failed, hers never did and for that I am most grateful of all.

# Abstract

Following a review of the paradigmatic context of broch towers in 2012, a revised standard model (the RSM) was defined. The then prevailing paradigm supports a view of broch remains as single monuments of highly variable form that continued in use over perhaps a millennium or more, without significant modification of their original tectonics i.e. their people/constructed-space relationships. This thesis challenges the pre-2012 paradigm by testing the hypothesis that brochs were built to the standard canonical form of the RSM and that their apparent diversity results from anthropic and, or natural modification, not design variability. The fieldwork tests could but did not find refutation of these hypotheses in the observable evidence and offered more profound interpretations of several surviving feature-types.

The loading on the stone lintels of the entrance passage through the massively built outer wall and the structurally overlaid inner wall created a major structural challenge, evoking a complex engineering solution. Its elements were individually noted pre-2012 but the significance of the engineering response to compression management had not been identified. This structural response was necessary for a tall structure with massive loads, and meaningless without one and its elements are therefore, jointly and severally, clear diagnostics of a broch tower. The entrance engineering was probably the inspiration of one individual or of a small group of master mason-types, not vernacular responses, contra the 2012 paradigm. Isolated stacked voids high in the inner wall are relict features indicative of significant modification of the inner wall. Other anomalous features are shown to be relict stacked void fragments.

The East/West differences in brochs across Scotland have long been identified and these are generally attributed to their lithologies. Accepting that, this thesis argues that the principal differences are attributable to the social processes that gave rise to centralisation of settlement around, in and over brochs in the east and north, possibly during the first century BC, and the absence of centralisation in the west; perhaps also explaining the differences in the scale and composition of the artefact assemblages between the two zones.

The canonical form facilitates calculation of the relative social costs of broch building for hard-rock and sedimentary stone types. This indicates that the costs of building, increase between 16-, and 32-fold over the buildable range of brochs. Constraints of design down-scalability, design weakness in ground loading, and design cost were major constraints on the mind of the broch builders. Canonicity and the limitations of drystone building technologies predicated specific forms of decomposition on the canonical broch, further complicating their autobiographies and their conservation: the main challenge now being that of finding ways to conserve the evidence for a sequence of processes while conserving the products of those processes.

# Chapter 1. The long prologue

## Introduction

The term  $\text{-builder}$  in this study of Scottish Iron Age broch towers includes the initial commissioning agent, the architect-equivalent and the stone workers involved in the project. They were no doubt supported by other parties, supplying food, ropes, wood and scaffolding, unskilled and infrastructural-support labour as well as protection for the emerging monument and its workforce.

Models for Iron Age society are often based on the historiography of the Irish Early Medieval Period and these are innocent of female wrights or *céardai*. However, it would be hard to imagine a social building programme, like a broch building project, in which women, and indeed children were not engaged.

In the simplest imaginable form of construction project, a single ruler<sup>1</sup> may have decided to cause the construction of a broch and used their domestic labour force to build it. In more complex scenarios, the commissioning ruler could have appointed a possibly peripatetic master tradesman to undertake the work and the latter would have directed the local labour force, leavened with some more skilled tradesmen. MacKie, distinguishes between commissioner and builder at Dun Carloway (MacKie 2007b, 1099). In commenting on Dun Telve, he further speculates that the same  $\text{-man}$  i.e. the same construction management team may have also built Dun Dornadilla and Dun Carloway (MacKie 2007a, 622), tacitly supporting the concept of peripatetic consultants and static commissioners.

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<sup>1</sup>  $\text{-Rulers}$  in the sense implied here, are, persons capable of marshalling the resources necessary to build a broch tower. The concept of  $\text{-ruler}$  in the Iron Age rests on retro-diction from what is known of the succeeding Early Medieval institution of kingship and this is a tortured subject (see Charles-Edwards, T M, M E Owen and P Russell (2000). *The Welsh king and his court*. Cardiff, University of Wales Press. Jaski, 2000 #977 }. In Ireland and Scotland, rulers of the period took the title Rí, or king, in respect of areas of land ranging in size from less than a modern parish to the entire island of Ireland or nation of Scotland. In addition, members of the aristocracy enjoyed considerable freedoms ó if they abandoned their  $\text{-king}$  he could no longer claim that status for himself. For the survival of itinerant kingship in Germany into the eleventh century, see Bernhardt, J W (1993). *Itinerant kingship and royal monasteries in early medieval Germany, c.936-1075*. Cambridge, Cambridge University Press.

It is highly probable that a professional wright acted as master mason or even as architect in the transmission of the concept to the built reality. In Irish languages (*Gaeilge* and *Gaelic*), these persons are termed *céardai* meaning smith or wright. The commissioner's idea, the *céardais* plans and the working practices of the work crews all constitute the 'mind of the builder' because all contribute to the processes of first envisioning and then constructing the envisioned.

The mind of the Iron Age builder is generally conceived of as a male entity, i.e. his mind. The masculine pronoun is sometimes justified because, despite some indications of women in senior roles in Iron Age society, e.g. Queen Méidbh, the prevailing narratives are heavily homocentric. Early Christian monastic bowdlerisation may have formed or contributed to this view, but currently little has been written to the contrary and even the erstwhile matrilineal Picts have been revised to conform to the assumed patrilineal norm (Woolf 1998, Woolf 2007, 28). The writer will continue in this admittedly sexist tradition where it serves the reader's convenience or avoids tedious circumlocution, but the role of women in Iron Age society deserves better treatment (Ehrenberg 1989; Hawkes 1990).

The process of approaching the mind of the builder used in this thesis is that of trying to identify the major constraints on the builder's freedom of choice. This exploration tries to identify the interlinked set of constraints arising from the physical, social and cultural contexts of the building. These are not recoverable from the non-literate societies of the Scottish Iron Age; nonetheless the perception at the outset was that the knowable constraints could sketch an inhibited decision-range.

## Broch towers

Circular in plan with surviving remains up to c.13.5m high, broch towers are without clear antecedents. They apparently emerge as a fully developed form<sup>2</sup>. The nature of their initial use is contested but once built, they remained in use over the following half millennium or more. Finally abandoned as functioning structures, perhaps

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<sup>2</sup> In the fourth or second century BC, depending on the authority consulted

around AD 400, the majority were effectively expunged from social memory albeit that the loci of their construction found repeated reuse in *ad hoc* roles ranging from early medieval burial mounds to sites for modern illicit whisky stills and sadly, and most commonly, as stone quarries (Tait 2005).

The dynamics of the building process and of the processes of continuing use and decay dominate this story of the brochs. It is, therefore, proposed initially to situate this study within a framework of Evolutionary Theory (ET) because of ET's demonstrable success in addressing issues of initiation, phylogenetic diversification and extinction, together with the aetiology of emergence, modification and decay (Gould 2002). ET does not seem to have been expressly applied to architecture or architectural history, but the literature is replete with the idea of development of one form from another. That these do not use the terminology of Darwinian evolution is readily explained by the many abrupt changes in form and design of structures over time and linked forms are spoken of as 'developments' from one to another. The gradualism of Darwinian evolutionary models is not compatible with the sometimes abrupt changes in architecture but gradualism is not a precondition of all evolutionary models and Lamarckian evolution, which embraces changes from experience and thus can absorb abrupt changes also, seems to offer a relevant and useful framework from within which to consider broch towers (Lamarck 1801, Lamarck 1914). Darwinian evolution is founded on the idea that breeding pairs produce offspring whose intermixed genes ensure a constant supply of phenotypical<sup>3</sup> changes, some of which may become dominant traits if they make the organism better fitted to meet its environmental challenges. Lamarck, unlike Darwin, believed that traits acquired during life could become heritable. Structures can be modified even during their primary use and even to the scale of significant alterations to their tectonic scheme<sup>4</sup>. Furthermore, some or all of these modifications can be built into

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<sup>3</sup> An organism's phenotype is all of its observable characteristics.

<sup>4</sup> Discussed further in Chapter 2, tectonics may be seen in part as the way in which the whole of the structure is greater than the sum of its elements and partly as the core people/place relationship between the structure and its users.

the next generation of such buildings. Thus, Lamarckian evolution is an appropriate model for the consideration of structures. Darwinian evolution is characterised by sequential changes, mostly small in scale, but Lamarckian change can be large scale and immediate, and can run counter to a prevailing evolutionary trajectory.

Darwinian evolution is gradualist and undirected, i.e. it is not targeted upon some universal optimum<sup>5</sup>. Lamarckian evolution can be abrupt and targeted<sup>6</sup>. Architectural change can also be targeted on a specifically defined goal tangential to the structure's development, like crystallising finance<sup>7</sup> (Moore 2012, 7) or building the tallest building in the world (Ali and Moon 2007, 207) or extending access to shorelines<sup>8</sup> or the creation of a nationally iconic structure (Johnson 2007, 186-7). Underpinning these and other motivating forces lies the cost of building which ultimately determines, if, what, where and when buildings are constructed.

## The urge to build

Le Corbusier's first men, designing and building their axial house within a rectangular enclosure in a cleared woodland area, were operating 'by the light of uncorrupted reason' (Rykwert 1981; 15), it is supposed. Rykwert implies that virtually every aspect of every building resulted from conscious cognitive<sup>9</sup> processes. This study explores some of our earliest prehistoric building traditions in an attempt to discover the framework within which their builders' cognition held sway.

John Ruskin defined architecture as all of those elements of a structure that are not essential for its structural integrity and argued that the latter constitute the field of

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<sup>5</sup> The writer asserts that humans are not the pinnacle of evolution and the evolutionary process was not geared to their creation, contrary to the views of some religious or faith based commentators.

<sup>6</sup> Discussed further in Chapter 2.

<sup>7</sup> <http://www.thenational.ae/business/banking/amlak-finance-to-provide-mortgages-for-serenia-residences-in-dubais-palm-jumeirah>

<sup>8</sup> (<http://www.visitdubai.com/en/pois/palm-jumeirah>)

<sup>9</sup> In this context, cognitive means relating to the mental processes of perception, memory, judgment, and reasoning



structural engineering, or 'building' in Ruskin's terminology (Ruskin 1910, 9). Engineering, expressed through the available technologies and materials, defines some part of the potentiality-envelope within which construction is possible. Engineering constrains the freedom of choice of the builders in a way that architecture does not. The measures deployed to meet the requirement for structural stability are enjoined upon the builder, i.e. are a constraint rather than a freely made choice, other than between alternatives. Architecture (*sensu* Ruskin), on the other hand, can be deployed free from any physical constraint although it is of course likely to be constrained by any or all of the contemporary zeitgeistic social and aesthetic norms or by religious observance.

The global universality of building hints that at even more fundamental levels, the urge to build may not arise solely from rationally determined human decisions but may derive in part from inherited and evolved modes of behaviour. The individual in prehistory, with inherited drives, constrained by technologies, materials, and social, religious and aesthetic conventions, and urged to build by ethological forces, may also have striven for some idiosyncratic expression of 'self' in these early structures. Archaeologies of the mind strive to disentangle these interwoven strands of motivation and constraint.

The materials and technologies involved in early construction survive in the physical remains of structures and this study is principally based on observation and analysis of extant remains, and deductions arising therefrom. The resulting account is in fact an interpretation and subject to those biases to which every generation of archaeological and architectural investigators is subject. The cultural dimensions of the structure, its social, political and economic contexts, are even greater abstractions and rather more open to the operations of contemporary bias. It is far from certain, for example, that terms like 'social' or 'socio-economic' can even be used without hopelessly biasing the range of available conclusions; time may prove them unhelpfully anachronistic. This reinforces the need to strive to reduce the scope for cultural determinism in exploring early structural remains. It may not prove possible to accept the idea that conscious thought alone, or predominantly, guides all the decisions associated with the conceptualisation, planning, building and the use of

structures, or with the iterations of any or all of these processes through reuse or following natural and anthropic destruction.

In short, then, the principal focus of this study is humanity and the study of structures is undertaken to facilitate observation of the decisions of human builders, individually or in cultural aggregates, by understanding the constraints-envelope within which they operated.

Built structures are synonymous with human activities and we have become accustomed to thinking of the genesis, construction and use of buildings as functions of humanity's cognitive capacity<sup>10</sup> and as both the products and the repositories of human cultural knowledge. Buildings that form urban centres were believed by Childe to be the first criterion for the definition of a civilisation (Childe 1950) albeit that others had attributed that status to possession of written records (Morgan 1907). In contrast, Trigger insists that

-A useful definition [of a civilisation] must therefore be constructed within a social anthropological framework (Trigger 2003, 44)

instead of, it may be deduced, from observation of the physical remains themselves. As indicated, the social, economic and political structures used to characterise civilisations are deductions or inferences drawn from observation of the physical remains of the cultures involved. If the structures are used to characterise the social, economic and political forms of the cultures, the latter can only be used to characterise the structures if we can accept a rather monstrous circularity.

Few, if any examples survive of cultures that do not build; even the Fuegians<sup>11</sup> (Gusinde 1966) make shelters of wood and leather which they moved from place to

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<sup>10</sup> *Sensu* Renfrew, C and E B W Zubrow (1994). *The Ancient Mind: Elements of Cognitive Archaeology (New Directions in Archaeology)*. Cambridge, C U P. evidence for an original conscious capacity that is recoverable as an inference from patterns of archaeological deposits or structures.

<sup>11</sup> A hunting - gathering culture, regarded by Darwin as the least civilised of peoples, who inhabit Tierra del Fuego and adjacent lands.

place in their hunting cycles. There are many areas on the planet in which humanity could not establish permanent settlement without access to the artificial environments that buildings create. Indeed, faced with the overwhelming association of mankind and buildings, we may be forgiven for believing that building is our defining specific difference with the implication that it was a skill humanity developed only after it had crossed significant evolutionary thresholds dividing man from animal. And yet, the largest structures on earth, visible from space, are coral reefs built by minute creatures to which none of the cognitive functions of humanity are attributed. Large and small structures built by non-human animals are attributed to instinctive drives hard-wired into the animals while, as noted, it is generally assumed that anthropogenic structures in almost every detail result from conscious cognitive decisions of their human builders (footnote 9). However, it was not always thus. Francesco Milizia (as cited in translation by Rykwert 1981, 66) suggested:

Man is impelled to build without much reflection, as he is impelled to drink, to preserve himself and to perpetuate himself, and as the beasts are impelled to song, to flight or to swimming. And what a distance there is between instinct and art, and between art and science. (Milizia 1781, Vol 1, i)

Milizia founds on his conception of the development of early building as seeing to commodity first, then to firmness, and finally to beauty (Rykwert 1981, 67); a reference to the Vitruvian tag, (ibid) the order of which is reversed in the structure of Milizia's three-volume work. The latter starts with architectural beauty and ends with building construction. Stripped of its charmingly archaic linguistics, Milizia's proposal is for an evolution from nature-in-mimesis via craft/art development, to consciously and logically designed and implemented, i.e. cognitive, architecture. This is an exercise in false etymology, as indeed are many of the examples from sources cited or interpreted in Rykwert, and this example more than most, is also reductively teleological. Its value lies in the clarity of its exposition of the perceived relationships between observation, artistic composition of the observed (Milizia's "beautiful nature") and scientific (*sensu* knowledge from causes) construction, each of which is a higher-level abstraction from its sequential predecessor. Semper's consideration of developing structural complexity as at least in part a response to the

materials of their formation is closer to the excavated record (Semper 1989). Perhaps Semper's concentration on the surviving materials as an evidential base has distanced him from speculations about the evolution of human intellect and the social determinism to which this leads.

The scheme outlined by Milizia conceives of the whole of architecture's development as an evolutionary subset of the intellectual evolution of *Homo sapiens*, a feature it shares, in terms, with all of the other case studies selected as evidence by Rykwert (Rykwert 1981). However, current studies in animal behaviour indicate that this is neither the only nor the best framework from within which to consider early architecture.

The eusocial animals<sup>12</sup>, ants, termites, bees and naked mole rats, are amongst the most assiduous and accomplished of builders. Termites, are known for the enormous volumes of their colonies, of which, John Maynard Smith once famously asked 'which termite has the plan?' (see for related discussion Dawkins 1982). The force of his question becomes clear when we note the complex and highly structured organisation of termite mounds and the sheer scale of the structures in comparison with the individual termite. The mounds are, typically 6m and can be up to 20m high while their wells can be over 46m deep. Scaled-up from termite to human scale (x600) these structures would be up to 12 km high and 28km deep respectively. Smith's point is that no individual termite has the plan and that the ordered state of the termite mound arises from the aggregate building behaviours of creatures with relatively simple but cognate drives.

Archaeologists and human geographers tend to interpret human settlement patterns in terms of social responses to environmental drivers like resource availability (see, for examples, Chorley and Haggett 1970). Architectural writing often implies the belief

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<sup>12</sup> Eusocial in this context means species in which there are multi-generational hierarchical systems with co-operative care for the young and a division of labour based on reproduction. With the exception (usually) of one female and a small number of fertile males, the individuals of the species sacrifice their individual reproductive rights for the greater evolutionary advantage of the community.

that cities arise from conscious planning decisions and that cities can be formed *de novo*, as design exercises rather than awaiting evolutionary responses to consistent challenges. Aldo Rossi's rejection of naïve functionalism as inappropriate for the study of cities is trenchant but can only be true for cities already so well developed that they change the environments in which they lie (Rossi 1984, 46-9). For smaller settlement aggregations, the reasons for the selection of locus is certainly a worthy research question. It is probable that geomorphological advantages for agriculture or defence or waterborne or trans-montane and cross-desert trade will have influenced selected locations.

This is not to exclude aesthetics or the many other anthropic factors adduced mainly in Phenomenological writings on monuments in landscapes (see for examples Tilley 1994, Nixon 2006, Johnson 2007), simply to assert the framing effect of pragmatics in the first instance<sup>13</sup>. Later, as Rossi implies, the successful city becomes its own environment with its own centres of social and economic mass and becomes also the principal driver in its own ongoing evolution<sup>14</sup>.

Few professional writers allow the possibility that settlement patterning at whatever scale may be driven, even in part, by ethological factors innate to human animals. Perhaps echoing the central proposition of Marais's observations on *The soul of the Ape* and on *The Soul of the white ant* (Marais 1989) it is argued here that while some animals experience the tides of evolution as individuals, others evolve as collectives and *'homo socialenis'* falls into the latter group<sup>15</sup>. That this emphasises the

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<sup>13</sup> Brochs as monuments in landscapes is addressed further in Chapters 8 and 9, but is not a major concern of this thesis. However, a brief account of landscape archaeology approaches is appended at *Appendix Ruins in a Landform*, q.v.

<sup>14</sup> It will be argued in Chapter 8, that on a humbler scale, the abandoned and ruinous broch also becomes the context of its own ongoing evolution.

<sup>15</sup> Whether this implies a progressive hive development amongst city dwellers, with its implication for restricted breeding access for males, remains to be seen but the plummeting sperm count of western city dwellers may be an early indication of a trend in that direction albeit that a myriad of causes are under investigation (Sharpe, R M (2012). "Sperm counts and fertility in men: a rocky road ahead: Science & Society Series on Sex and Science." *EMBO Reports* **13**(5): 398-403.).

importance of social decisions for the emergent Social Man, is acknowledged, and it is not proposed to suggest that society has no role in development decision-making, simply that social factors are one of two classes of constraint, the other being environmental (*sensu lato*) and neither can be written out of consideration.

The biological point to life is reproduction. Survival to achieve reproduction means locating and acquiring food, avoiding death from predation, exposure to the elements or accidents, finding and attracting mates and for some species, including humans, providing for their young (Gould and Gould 2007, 3). We may speculate that protection of the young provides a particularly strong stimulus for animal architects. Certainly, structures associated with rearing offspring, e.g. the nests of birds and insects probably constitute a majority of animal structures. Direct comparison of animal and human behaviour can merit outright rejection as anthropomorphisation but modern studies of animal behaviour invite us to consider again the potential extent of humanity's physiological inheritance (see for example Mulder 1991; 69-98), an invitation also posed in ethological studies (Eibl-Eibesfeldt 1989).

### **Forms of learning**

Gould and Gould (2007, 16 *et seq*) deconstruct the process by which the pipe wasp builds its tubular nest affixed to a vertical surface, to illustrate the interplay of instinctive and learned behaviour in the construction of the nest. Cumulatively, they recognise a range of knowledge types which we summarise here into three classes, with the proviso that the classes are not mutually exclusive and that there are no natural boundaries between them. The first class is that of the purely instinctive knowledge expressed mainly in simple reflexes, like egg recovery or flinching on touching a hot surface. The second class, operant learning, adds the potential for great flexibility and adaptability in articulating the relationship between the instinctive knowledge and the realities of the outside world. Thirdly, they recognise a class of intellectual or cognitive knowledge based on cognitive learning (see eponymous section below for description of the use of the term 'cognitive').

## **Instinctive learning**

Early studies in animal behaviour distinguished between instinctive and learned behaviour as an either/or paradigm for observed patterns of behaviour, including building. Apparently complex behaviour, like the retrieval by ground nesting birds of eggs fallen outside the nest, seems to be directed and intelligent. However, as Lorenz and Tinbergen showed, the absence of any alternative method should have raised suspicions. The fact that the retrieval process will continue to its end, without variation, even if the egg is removed part way through, confirms that the behavioural process of egg retrieval is indeed hard wired in these species (Lorenz and Tinbergen 1938). Neurobiologists have now traced the neural networks deployed in the egg retrieval process, cell by cell, and shown that the behaviour is generated in a way analogous to computer programming, because the muscles are programmed in sequence to achieve this relatively complex behavioural pattern. These neural nets form a motor program and motor programs may be the building blocks of some behaviour, even some of the complex behaviour associated with building (see Gould and Gould 2007, 7; which is relied upon here). Motor programs constitute a significant part, possibly all, of what is more loosely called instinct

## **Operant Learning**

Imprinting, the process by which young animals recognise their parents uniquely, seems indicative of a modified form of instinct sometimes called conditioned learning. The fundamental need to identify a parent is clearly pre-wired in the emergent young and some knowledge of the target group of potential parents may also be assumed; otherwise goslings would follow any moving object, a cloud, perhaps, or (briefly perhaps) a predatory seagull. However, the characteristics by which a specific young animal uniquely identifies its individual parents (or parent substitutes) cannot be pre-programmed. The young animal must learn which features are uniquely diagnostic of its own parents. Gould and Gould (2007, 11) term this process operant learning and note that the young have built-in biases that ensure they select and remember the correct cues. In other words,

–Animals know how to process the cues they must attend to, when they encounter the stimuli they innately know define a specific learning task.ø(Gould and Gould 2007, 12).

However, even this slightly less deterministic meaning for the term –instinctøcannot explain all animal behaviours. Certainly, it is possible to hypothesise that complex animal behaviour is created just by stringing together sequences of simple reflexes. But, Skinner has observed that complex animal behaviour, while relying in part on such constructed complexity, also relies on trial-and-error experiences of the animal (Skinner 1960). Learning by experience to extend or modify instinctive knowledge is termed –operant learningø

### **Cognitive Learning**

In the study of the origins of building by humans, archaeologists, like architects, often assume that virtually all of the early decision-making processes involved are informed only or predominantly by cognitively acquired knowledge, and conversely believe that all animal building is purely instinctive ó by which is imprecisely meant unconscious processes that are biologically predetermined. Relying upon Gould & Gould (2007 Chapter 10) the range of relationships between building activities and the emergence of the human mind deserves a little more exploration.

Humans may attribute to non-human animals a measure of flexibility derived from operant conditioning which perceives them as allowing new stimuli to trigger old responses or old stimuli to trigger new responses. However, this dispensation alone would not account for their ability to form conceptions and to modify them, exemplified in the repair work that some species undertake on their constructions, most notably, weaverbirds and bowerbirds (Goodfellow 1977: Frith and Frith 2004). At minimum, this requires that the animals possess a more or less clear image of what ought to exist and can make the necessary amendments to a damaged structure to realise that image. Gould and Gould note that;

–The ability to skip unnecessary steps, to take advantage of or compensate for unusual contingencies, to find alternative solutions to a problem, and to use novel materials may suggest more than a picture; in these situations, animals may



have some understanding of the goal, the needs to be met.<sup>ø</sup>  
(Gould and Gould 2007, 279)

These behavioural modes are indicative of a capacity for planning, i.e. for mapping out (or  $\rightarrow$ network planning $\rightarrow$ ) behavioural choices. In turn, the degree of flexible mental extrapolation inherent in planning seems unattainable in the absence of an understanding of the goals of the constructional activities. Understanding, which requires extrapolation and orchestration of behavioural units necessarily requires the animal to appreciate to some degree the cause and effect relationships between materials, forces and its own potential actions. This description is readily applicable to human building.

Finally, the use of tools, increasingly documented for species as diverse as chimpanzees and crows, points also to the existence amongst animals of insight and planning. New Caledonian Crows make hooks from strips of wire and use them to access food, in laboratory conditions (Hunt 1996, 251). This behaviour seems to adapt and extrapolate from  $\rightarrow$ instinctive $\rightarrow$ knowledge<sup>16</sup>, possibly by a rearrangement of the behavioural elements from which the natural behaviour is compounded. The use of tools by chimpanzees is similarly well documented and similarly indicates some degree of individual consciousness of cause and effect. Scholars at Cambridge University have recently launched a new arena of study called  $\rightarrow$ Primate Archaeology $\rightarrow$  which applies the methods of  $\rightarrow$ human $\rightarrow$ archaeology to the physical remains created by the actions of primates (Haslam, Hernandez-Aguilar *et al.* 2009 339). The use of tools by chimpanzees and the incidental creation of deeply pitted stones by repeated crushing of nuts at the same site create artefacts that would not be out of place on hominid sites, even on those of relatively recent date.

The evolution of knowledge from the instinctive, through operant, to cognitive learning would have been reinforced in a positive feed-back loop as emerging intelligence fostered survival by improving food-take, procreation and offspring survival. With many, perhaps most, of the animal exemplars noted above, however,

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<sup>16</sup> In the wild, they fashion hooks from twigs and use them to collect grubs

the buildings constructed by the animals involved seem to have become invariant and there is virtually no recorded evidence for the development of building-types over time. Human building, in contrast, has varied and human structures have diversified over time at increasing rates of change. With no successful predators, the imperative for change arises mainly from intra-species competition, i.e. competition between peoples. Thus, for example, the expressed rationale for changes in the form of military fortifications in Europe post-1500 is said to have been the development and spread of more effective canon guns and muskets (Cruikshank 1999, 812) and perhaps the popularity of war. Familial aggrandisement is similarly adduced as the reason for building ever taller towers in Italian towns during the late and post medieval period (Roversi 1989, 11-29).

The existence of a continuous spectrum running from instinctive, through operant learning, to apparently cognitive behavioural modes in animal building processes are evidenced before the evolution of modern hominids. This ought, at the very least, to suggest the possibility that human building activities, from conception to completion, need not all be the result of conscious, cognitive, decision making alone (*sensu* footnote 9).

It is of course accepted that the scope for instinctive and operant learning in the drive to build was most forceful in the very earliest building, possibly in the Upper Palaeolithic, or earlier if modified caves and rock shelters are to be considered. However, initiations have been many and varied in human history amongst peoples severed from contact with parent groups by migration, disease or war. Service notes that:

¶ a large number of the societies included in the Human Relations Area Files do not have an aboriginal social organisation; many have, in fact, the organisation, or lack of organisation, of a displaced persons camp.ø(Service 1971, 8)

Such groups are unlikely to have retained the capacity for a coherent knowledge-based architecture and would have resorted to primitive shelters. Similarly, there are periods in prehistory in Scotland, like that from roughly 2000 BC to perhaps 400 BC during which structures reduce to a lowest common denominator of simple round

houses built mainly or entirely of wood. It must be assumed that during this interval the contribution of architecture to society was not considered significant and for the vast bulk of the population it had diminished to vernacular structures of some utility but little architectural accomplishment. Acknowledging the sterling work of scholars like Rachel Pope and Tanja Romankiewicz on round houses and acknowledging also the efforts of others to breathe life into their study, often through reconstructions of round houses, it is tempting to paraphrase Stephen Townsend's title 'What have reconstructed roundhouses ever done for us...?' by the omission of the term 'reconstructed' (Pope 2003, Romankiewicz 2011 Townsend 2007). Harding and others have imputed 'monumentality' to roundhouses, again probably using the term as a synonym for 'massiveness' (Harding 2009a, 59) but certainly indicating that the larger and better built examples were probably not vernacular constructions. Accepting that the larger wooden roundhouses may have been 'polite' structures, as opposed to vernacular builds, and that their massing could be impressive, the writer still fails to see them as *Monumental* or memorialising in the sense discussed in Chapter 2.

Once fully artificial buildings were constructed, the intellectual environment in which further decisions about building would occur was altered, both by the existing buildings and by the building technology, or the 'traditions' or habits of building that they initiated. In exploring the human minds behind the building of prehistoric structures, we need also to consider those aspects of design and build that are predicated by non-behavioural factors, amongst which the more important constraints include available materials, limitations on the available human resources and the ability to manage increasingly complex building projects. These will be discussed in the following chapters but here the problem of managing complex building projects is briefly considered. A complex building project, as defined here, is one in which the concepts of one human are translated into interrelated streams of clear instructions, received and reissued as required by other humans, so that a significant project can be completed as originally conceived and intended. Again, the animal world indicates the potential origins and management of social building projects. Gould and Gould, argue for three degrees of social intelligence exhibited

mainly in the eusocial or near eusocial creatures, and this scheme is reproduced here in Table 1.1

**TABLE 1.1 Social Intelligence in Animals (after Gould & Gould 2007)**

<i>Social 0</i>	Social isolation: conspecifics are either ignored or attacked.
Social 1	Social hierarchy: animals have a linear representation of part or all of the social order, especially individuals ranked near the individual in question.
Social 2	Decision-network mapping: multidimensional representation of parameters is important in making social choices.
Social 3	Attribution and intention: animal has an ability to understand the cognitive processing in the brain of a conspecific, and can alter its behavior to exploit that knowledge.

To take a single illustration, the nests of eusocial creatures are extended, altered and repaired over time, and the contributions of the separate builders indicate that each of them knows where s/he is in the overall structure or structural alteration underway. This requires a degree of flexibility compatible with social intelligence of the level of Social 2 (Table 1.1).

Increased levels of social intelligence are also indicated by the cognitive processes involved in the initial siting of the structure and the processes of site selection, which indicate a heightened level of personal and geospatial mapping by the creatures involved (Table 1.2). The geolocational abilities of many animal species are well known, not least from the remarkable migrations undertaken by some of them (see, for example, Elphick 2007, for discussion of bird migrations). Their ability to travel extremely long distances are often dismissed as instinct or the playing out of a genetically pre-programmed routine free from any taint of cognitive ability. However, even amongst the birds there is clear evidence for their synthesis of integrated inputs from magnetic, solar and stellar compasses (ibid, 30-1) and, in some cases, polarised light, wind directions and local topography are also considered. The geolocational abilities of bees, as von Frisch has shown, are also not reconcilable with simple instinctive processes alone (Von Frisch 1967). This ability is exemplified in their selection process for a new hive site. From the prospecting swarm, individual bees explore the surrounding landscape for sites that meet their

criteria. On finding a site they return and dance its direction and distance for their colleagues. Pioneer bees visit sites discovered by others and over a few days, a consensus gradually builds favouring one site over all others, and the swarm moves there and takes up residence. In selecting a suitable site for the new hive, the bees have a specific set of requirements clearly in mind and experiments (Seeley 1982, Seeley, Visscher *et al.* 2006) have identified the following criteria as significant for the decision makers; height above ground, volume (between defined min and max values), space taller than wide, unobstructed south-facing entrance, dryness, freedom from drafts and distance from the original hive (see Gould and Gould 2007, 118, for

**Table 1.2 Mapping in Animals: (After Gould & Gould 2007)**

Tier 0	No spatial representation: independent Stimulus-Response wiring for stimuli
Tier 1	Internal map: spatial representation of stimuli impinging on body: typically, tactile.
Tier 2	Surround map: spatial representation of objects and surfaces immediately around animal (within one body length, typically mapped by touching); generally tactile.
Tier 3	Local-area map: spatial representation of local objects not within one body length, allowing local navigation through interpolation and pattern matching: typically, visual, tactile. Olfactory, or auditory.
Tier 4	Cognitive map: spatial representation of the relative position of widely spaced objects or other landmarks, allowing home-range or nest-interior navigation based on a cognitive map; typically, visual or tactile.
Tier 5	Network mapping: multidimensional representation of space, tool and/or building equipment, goals, and behavioural options; potential for innovation.
Tier 6	Concept mapping: abstract reasoning, concept formation, potential for insight and language.

further discussion).

The observations on animal behaviour reveal the use of extensive conceptual powers in all aspects of animal construction projects ranging from site selection and construction to management, repair and reconstructive alteration.

The independent evolution of building skills in different species emphasises their survival value, which presumably subsists mainly in the environmental control possible in a built structure, together with its food-storage capacity, security and relative permanence. But building changes both the operational environment of the builder and the builders themselves. Indeed, the thesis of Gould and Gould (1970) is that building both facilitates the evolution of intelligence and propels it onwards by presenting the animals involved with new challenges and new possibilities. They conclude that:

-We are the ultimate inheritors of a drive hundreds of millions of years old to build, and thus take charge of the immediate surroundings. For better or for worse, this architectural drive eventually created the kind of mind we now possess. (ibid, 299; my emphasis)

## Conclusion

It is argued here that the primary human urge to build is largely innate and that architecture, in current descriptions, may best be described as the conscious cognitive rationalisation of an impetus that is older than *Homo sapiens*. Moore suggests that the commissioners of great buildings put their faith in the power of building to make real, or at least physical, their desires;

[Buildings] í are the mineral interval between the thoughts and actions that make them and the thoughts and actions that inhabit themí ø (Moore 2012, 18 & 165).

From this initial cognitive motivation, he goes on to list social drivers for the building impulse ranging from the emotional to the symbolic. A more cynical reader might identify his interpretation as the *post factum* rationalisations of members of the architectural *weltanschauung*. However, in his final conclusion he suggests that,

-Architecture is like fashion, cuisine or love, the elaboration of something essential to existence...ø(Moore 2012, 392)

and with this acknowledgement that the architecture of the recent past and the present is a gloss on something infinitely more fundamental, we may find agreement.

In mapping the decision range of broch builders, this study therefore recognises no need to address the fundamental question, 'why build?' (pace Moore 2012) because our genetic inheritance supplies that impetus. In addition, and following a roughly 2,000-year period in which architectural engineering was restricted to the production of rather humble round houses, Iron Age social knowledge, the cultural mnemosac<sup>17</sup> of the period, had acquired sufficient sophistication to require a plethora of structural forms, of which the broch tower is perhaps the most intriguing. In consequence, the primary question for this thesis becomes, 'why construct dry stone built towers in the Scottish Atlantic Iron Age?' and the primary approach to answering this question lies in an exploration, via the surviving remains, of the motivations in the mind of the builder.

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<sup>17</sup> Discussed in Chapter 2.

## Chapter 2 Framework concepts

### Introduction

This chapter introduces the Iron Age broch towers of Scotland, stone built towers up to 15 m high, and up to 12 m in external diameter, shaped like truncated cones. Of the 600 that survive only 150 reveal masonry and of these only c. 80 reveal sufficient of their structural features to facilitate study and analysis (these are indicated by an asterisk beside the site names, in MacKie 2002, MacKie 2007a, MacKie 2007b and appear in Table 2.1, at the end of this chapter). The structural parameters of these monuments are examined in Chapter 3 while here some of the significant concepts developed in this study are set out. These include the idea that brochs may exhibit both *canonicity* and *mutability* and may have been created as acts of *aggrandisement* or *memorialisation*. In addition, the idea of a *real world* is contrasted with the world of the cultural knowledge, the *mnemosac* of a community.

Most of these terms have conventional meanings and some, like *monumentality* have a wide range of meanings, in this case ranging from *an ancient structure* to *an impressive set of remains* to *a structure built as a memorial*. Therefore, a terminological gloss is presented before their relevance to the current study is considered<sup>18</sup>. The tedium of terminological exactitude is pursued here, not to frame tendentiously the work undertaken but in an attempt to ensure that the writer is consistent and clear in describing that work.

### Terminology

The term *canonical* has evolved<sup>19</sup> to mean *of the nature of a canon or rule; of admitted authority, excellence, or supremacy; authoritative; orthodox, accepted;*

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<sup>18</sup> See also the Gazetteer in Appendix Gazetteer, for definitions of these and other terms. McGilvray, in 1988 suggested that many terms are used *rather interchangeably* to describe various activities and projects (McGilvray 1988) and his brief examination of a single issue of *Preservation News* revealed 32 separate terms used to describe activities associated with historical conservation and even more in the case of *heritage conservation*.

<sup>19</sup> From restricted origins relating to conformity with ecclesiastical canon law.



standardí ø(OED). The term ‘canonicity’ is used here to convey the sense of a brooch tower built in conformity with a canon or rule and for which orthodoxy and acceptability were established by reference to that rule. Conversely, the term ‘mutability’ means the possession of a capacity for change (Latin *mutare* to change; *mutabilis* etc) and it is used here to describe a deduction drawn from observation of patterns of alterations in structures. Drystone built structures are highly mutable because it is usually easy to remove stones and reorder elements of the structure.

A culture’s ‘mnemosac’ describes the package of all the available cultural knowledge accessible to it at a given area of space, time and cultural context. Vernacular processes are often mnemosaic and their products may vary significantly over short ranges while zeitgeistic phenomena, like architectural styles, may remain consistent in form over their entire range or produce a small number of regional variants<sup>20</sup>.

In the context of this study, objects that tangibly exist, i.e. that can be experienced by the senses, and the characteristics of whose existence are consistently reported under independent observation, are said to exist in the ‘real world’. This definition is consistent with Popper’s ‘world 1’

“There is, first, the world that consists of physical bodies: of stones and of stars; of plants and of animals; but also of radiation, and of other forms of physical energy. I will call this physical world ‘world 1’” (Popper 1978b, 146).

The term ‘monument’ is derived from the Latin stem for memory, viz, *memoria*, and is properly applied to structures that were designed to enshrine memories from the outset<sup>21</sup>. Some structures have come to be associated with memories<sup>22</sup> *a tergo*. These may be the offspring of a cultural ethos or a mnemosaic belief that is not contemporaneous with the original construction. This is a complex issue, discussed

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<sup>20</sup> The possibility that this results from contemporary intellectual categorisations rather than inherent properties of the categorised objects is considered below.

<sup>21</sup> These are Riegl’s ‘deliberate monuments’

<sup>22</sup> Whether those memories are real or imagined matters not one whit.

further below but from the outset a distinction is made between memorialising structures, like a cenotaph or a triumphal arch, here capitalised and italicised as *Monument/s* and other heritage assets visible to the unaided human eye at ground surface, to which the legalistic<sup>23</sup> or conventional term *monument/s* is applied. Riegl distinguished between deliberate *Monuments* and those traditionally defined as 'artistic and historical monuments...' (Riegl 1982, 69) and brochs are of the latter variety.

Armit has provided the following definition of 'monumental':

In the context of the present study, this term [monumental] will be taken to describe any structure in which the investment of skill and labour in construction greatly exceeds the requirements of structural stability. (Armit 1992, 21).

The relationships between constructed mass and stability are complex, bigger does not mean more stable, as this study will establish in later chapters, and increasing the mass of a structure alters its requirements of structural stability, the supposed basis of its definition. Implicit to Armit's work is the significance of the broch scale for the implied social commitment required to build or modify one, and this is a reasonable implication for a Large Complex Monument (LCM) which is explored

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<sup>23</sup> Consider, for example; "Monument" means (subject to subsection (8) below)-(a)any building, structure or work, whether above or below the surface of the land, and any cave or excavation; (b)any site comprising the remains of any such building, structure or work or of any cave or excavation; and (c)any site comprising, or comprising the remains of, any vehicle, vessel, aircraft or other movable structure or part thereof which neither constitutes nor forms part of any work which is a monument within paragraph (a) above; and any machinery attached to a monument shall be regarded as part of the monument if it could not be detached without being dismantled. (AMAAA (1979). *Ancient Monuments and Archaeological Areas Act 1979*. Edinburgh, HMSO. Or, "monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science; - groups of buildings (ensembles): groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science; - sites: works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view." UNESCO (2013). *Operational Guidelines for the Implementation of the World Heritage Convention*. UNESCO. Article 1; Clause 44; Part II.

further in Chapters 4, 8 & 9. What distinguishes the species of broch from other monument species are its scale and massing and, when excavated, its complexity<sup>24</sup>.

The term *aggrandise* means 'To enlarge, increase, magnify, or intensify [a thing]' (OED) and aggrandisement is the action or result of aggrandising. Applied to heritage assets, aggrandisement is a deduction about builders' intentions based on the observation of exaggerated excess in one or more of the attributes of the heritage asset. Arguably, therefore, Armit conflates his use of the term 'monumentality' with aggrandisement in his definition of monumentality.

## Canonical and acanonical monuments

If the forms of buildings were always rational expressions of personal creativity, there is no *a priori* reason to assume that they would all be identical or even similar; rather, heterogeneity would characterize the assemblage. Vernacular architectures are regionally constrained by the limitations of materials and construction technologies whilst displaying generic similarities, but, as will be demonstrated later, they are generally characterized by a higher degree of homogeneity than could be accounted for by resource constraint alone. Greater consistency is apparently evident amongst the categorical architectural types, Romanesque, Gothic, Modernist, etc, (Kostof 1995, Fletcher 1996,).

The first Gothic structure, Abbott Suger's<sup>25</sup> cathedral at St Denis, initiated a building tradition that has lasted for centuries and is still in use. This consistency was determined *a priori* and in practice developed a weight of tradition that contributes to its conservation. In this example, a standard model having been created and disseminated, a tradition of building in this form and style rapidly became established. However, and despite the homogenizing influences of initial design and

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<sup>24</sup> Thus, brochs are attributed in Chapters 7 and 8 to the generic category of Large Complex Monuments (LCMs).

<sup>25</sup> It is no longer generally accepted that the design of the gothic cathedral was provided by Suger himself, rather that his patronage allowed some now unknown master mason to express the cathedral in a new way (Rudolph, C (1990). *Artistic change at St-Denis : Abbot Suger's program and the early twelfth-century controversy over art*. Princeton, Princeton University Press.).

emergent tradition, individual variation is not ruled out (Figure 1). Convergent and divergent influences operate in tension and even well-defined architectural categories, broadly compliant with an *a priori* concept, exist in tension with regional, local and even individualistic divergences that could potentially give rise to corresponding sub-styles.



**Figure 1 Individualism sometimes finds expression in the strangest architectural fashions and even modest terraced houses can be personalized. (C S Lewis Tour of Oxford; Creative Commons License).**

The advent of a new form may challenge existing building traditions and give rise to variants. Ousterhout has described the rise of a regional style in terms of local craft responses to a newly introduced Byzantine brief for church building (Ousterhout 2008). He emphasises the

roles of the commissioning agent, often a churchman, the professional functionary who may be an architect or master builder, and the jobbing masons and other trade subcontractors. Ousterhout emphasises the creative tensions that arise from the commissioning agent's requirement for novelty from a *de facto* traditionalist workforce. Their interactions gave rise to a distinct, regional Anatolian sub-style of an otherwise canonical Greek-model Byzantine church (Ousterhout 2008).

For the purposes of this study, all of these supply-side participants, and some others (below), are the 'builder' and their 'mind' is a composite of their individual cognitions and the interactions between them. The use of an extended concept of

mind here may appear cognate with the work of some Cognitive Theorists such as Andy Clarke but this writer does not accept their apparent insistence on the principle that the cognitive mind extends itself by extra-somatic means into the 'real world' however conceived (e.g. Clark and Chalmers 1998, 12-13).

In considering the state of knowledge on brochs in 2012, the writer has defined as a standard model for that date (SM2012), not a model conceptualised *ab initio*, but rather the prevailing 'lowest common denominator' view of the broch. No single writer on brochs in 2012 would accept all the features predicated here upon the conceptual broch at that date, but considered as a group, it is probable that most would accept most of its proposed features. Conversely, the RSM is a single conceptual model constructed *de novo* by this writer from published sources and field observations.

The concept of canonicity is first approached here via a brief review of the introduction and emergence of a canonical architectural form during the pre-Romanesque Early Christian Period in Ireland and Northern Britain, and its converse, as demonstrated in the acanonical pre-Romanesque churches of Asturias. The transition to the Romanesque seems an appropriate metaphor for the advent of the broch. In the prevailing paradigm, both are related to a pre-existing melange of monument types, to elements of which they have severally been attributed as evolutionary descendants.

The coherence of the term 'Romanesque' is subject to scholarly criticism (Conant 1973, 4-5) but, taken simply as a mnemosac label attached to the concept of a distinctive style-set, its utility is not in doubt. Structures labelled 'Romanesque' are compounded from selections of surviving elements, derived from or inspired by Roman architecture, that were organised into new overall forms. These forms are

now generally measured against a mental model of 'Romanesqueness' and accepted or rejected by individual authorities, depending on their individual models<sup>26</sup>.

## Canonicity in Early Irish wooden churches

The wooden churches of Early Irish Christianity survive mainly as representations and skeuomorphs in stone,

**Figure 2 (right) Muirideach's Cross at Monasterboice, Ireland. The upper arm of the cross represents a wooden house-shaped structure with shingled roof and finial at the crossing of the bargeboards. The ridgepole is external to the roof.**



metal and vellum, and in the archaeological remains excavated at a handful of sites. The stone skeuomorphs are preserved as the finials of high crosses (Figure 2) and in so called

house-shaped burial shrines, the former rather more widely explored as art-historical subjects (Henry 1964, Stalley 1991, Harbison 1992) than the latter (Wakeman 1975). Fewer than a dozen metal reliquaries, like the Monymusk (Figure 3) (Anderson 1880) and Lough Erne reliquaries (Figure 4) survive and some of those only as fragments, e.g. the Clonard fragments (Floinn 1989, including, perhaps the ridge-piece referred to therein (ibid, 55). The vellum representations are somewhat ambiguous and the most frequently cited, the 'Temptation of Christ' scene in the Book of Kells (200 verso; Meehan 1994; 11: copied here as Figure 5) is possibly best

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<sup>26</sup> Architectural historians seem to categorise groups of structures in terms of weighted attribute-sets (different authorities applying different weightings to different attributes) and the groups are sometimes said to be necessarily mutually exclusive.



**Figure 4 (left) The Lough Erne Shrine. Although more stylised than the Monymusk reliquary casket this retains the essential forms of a timber frame-built structure**

**Figure 3 (right) The Monymusk Reliquary (c. 8th to 9th centuries AD), a house-**



interpreted as the representation of an Irish wooden church constructed in an Anglian building style.

The Irish monastery on Lindisfarne was founded by St Aidan, who had travelled from the mother house of Iona at the request of King Oswald in 634 AD to help establish Christianity in Northumberland (Stenton 1984). Aidan's experience of churches is likely to have been that of the simple Irish wooden church. The NE Angles built rectangular or slightly boat shaped timber houses in which the lateral thrust of the roof on the long side walls was counteracted by the use of long rafters whose ends were set into the ground or resisted by lean-to aisles (see Plates 105 and 106 in Hope-Taylor 1977 for images of three-dimensional models of the form). Attempts by Anglian craftsmen to construct to a brief prepared by Irish monks would have produced forms with elements of both traditions. The result would have been the modified version of a canonical Irish wooden church represented in the Book of Kells (Figure 5).



**Figure 5** The temptation of Christ scene from the Book of Kells (200 verso). The image of the temple emulates the characteristics of a timber frame-built structure with external ridge-pole and shingled roof but seems to represent the bargeboards as reaching the ground, an attribute of Anglian not Irish church building. The finials at the crossing of the bargeboards are however conformable with Irish insular art.

This directly parallels Ousterhout's observation of the construction of Byzantine churches by Seljuk craftsmen working to a Byzantine brief (Ousterhout 2008) and producing a regional variant that differs distinctly from the exemplar, albeit that the influence of the latter remains clearly visible. The converse is recorded in Conant's



identification of the late classical Roman as proto-Romanesque because, he argues that;

✎ The methods of commonplace Roman building were continued with little change during the Dark Ages in the southern and more settled parts of the Empire area, awaiting the time when a grander architecture should be possible.ø (Conant 1973, 43).

In this case, the survival in craft practice of a set of techniques and technologies facilitated the survival of a range of stylistic elements that could be, and were, variously combined and engrossed finally to produce the more dramatic Romanesque churches, castles and other buildings between the 6<sup>th</sup> and 10<sup>th</sup> centuries. McClendon suggests that from the mid sixth to the ninth centuries the functions of churches mutated to emphasise their reliquary chapels while at the same time:

✎ the relative simplicity and uniformity of the Early Christian basilican design [was transformed] into an array of shapes, sizes and decorative textures. The Franks, Lombards, Visigoths, and Anglo-Saxons attempted in various ways to emulate Roman techniques in design and construction, in keeping with the desire to legitimize their rule and new-found faith, but in the process they also introduced decorative qualities derived from indigenous traditions quite distinct from late antique aesthetics.ø (McClendon 2005, 195)

These contrasting consequences of the conservatism of the buildersø skill-sets highlight the relationship between inherently conservative constructional technologies and the creativity of newly envisioned built forms, from which locally canonical styles become established or are modified. The advent of new technologies, mainly the use of mortar in stone building, enabled the proliferation of new styles and of old forms in a new material. Correspondingly, some attempts were made to produce rectilinear buildings with dry stone corbelling and with rammed earth, but these pre-Christian building practices did not persist (Ó'Carragáin 2010, 17-18).



**Figure 6 Gallarus oratory, Dingle, Ireland. A corbelled oratory which may have been built with mortar. Its date is disputed but may lie in the range 800 to 1200 AD although some scholars suggest a much earlier, even pre-Patrician dates.**

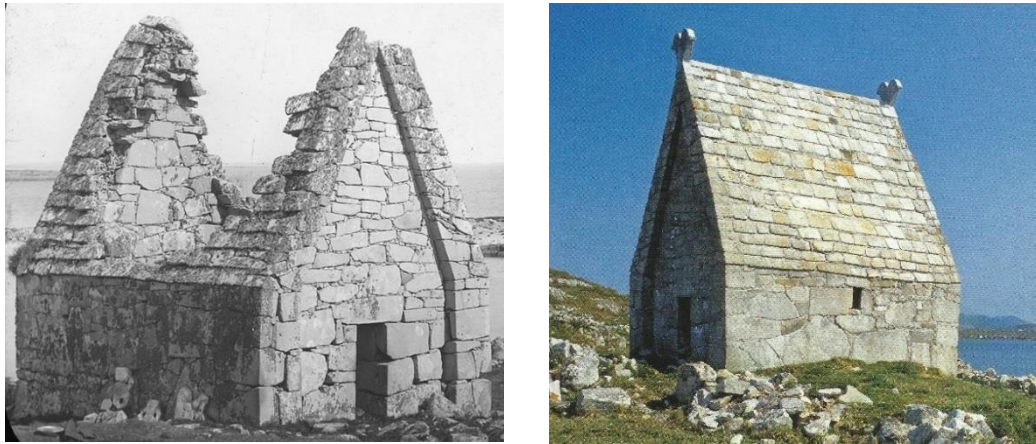
The small but exquisite oratories, like Gallarus, in Dingle (Figure 6) were attempts by craftsmen skilled in drystone tholos-building to copy a rectangular wooden church. This runs counter to Conant's description of Gallarus as 'an elegant translation into corbelled stone of the cruck house' – a suggestion that would have been more credible if any evidence existed for cruck houses in Ireland for this period, or for the following half millennium (Conant 1973, 31). In contrast the area around Gallarus contains over 700 tholoi of the *clochán* type<sup>27</sup>. Although Gallarus was corbelled, it is hypothesised that mortar was used, if not in the original build, then in subsequent repairs (Harbison 1970).

Leask's suggestion that the churches of the Irish stone-roofed series are skeuomorphs of the primal wooden church has latterly been supported by Ó'Carragáin (Leask 1977, Ó'Carragáin 2010). The claim that, being *in antis*, they derive from Mediterranean prototypes can be safely dismissed, given the number that survive with the *antae* projecting up the sloping gable wallhead to form finials at the roof

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<sup>27</sup> Conant's account of early Irish architectural history is not reliable and reliance is here placed here instead on the work of Ó'Carragáin, T (2010). *Churches in Early Medieval Ireland: Architecture, Ritual, and Memory*, Yale University Press., and on the 1977 work of Leask.

apex in skeuomorphic representation of the bargeboards of the original wooden frames (Figure 7).



**Figure 7** Teampul MacDara, Co Galway Ireland, before and after restoration. The supposed antae clearly project up the sloping faces and are skeuomorphs of the timber framing of the canonical early Irish timber-framed church.

The excavated evidence of such simple wooden churches derives from a handful of sites; Ardwall Island, in Scotland, and from Church Island, Carnsore Point, Ballygarran, Dunmisk, Derry and others in Ireland (see Ó'Carragáin 2010, 16, and Chapter 1 *passim*, for discussion but note that he interprets some of them, improbably, as wattle and daub churches, albeit that he notes that use of daub may

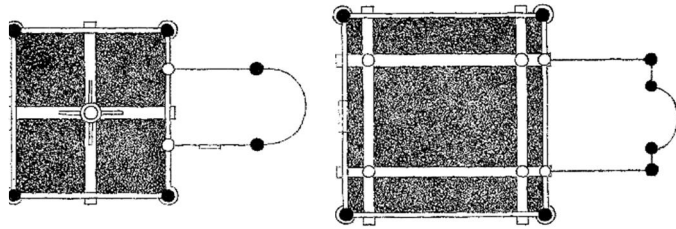


**Figure 8** The simple stave built church of Haltdalen, Norway. Note that the structure is supported on a stub wall, which is all that would survive the decomposition of the church.

not have been an Irish practice). It will be clear that these simple church plans may represent quite beautiful wooden structures. The truncation at ground level of the

exquisite Norwegian Stavkirken would leave remains no less modest than those of the excavated Irish and Scottish sites listed above, and in some instances, might leave

**Figure 10** Ground plans of a single mast stave kirk (right) and a Valdres type kirk (far right). Only the solid black posts would leave post holes.



**Figure 9** The stave kirk at Fantoft, near Bergen. This was moved to its current location recently and rebuilt following a fire, but its authenticity of form is not in question.

none at all, see for example Haltdalen, now in the Tromso Museum (Figure 8). The simpler stavkirken, rotted away to ground level would leave only post hole settings to represent them (see Figure 10, after Lindholm 1969, 30). Even the most complex of the wooden churches (Figure 10) would leave only a few postholes

The Hiberno-Scottish remains, together with their artistic representations are interpreted as indicative of a frame-built wooden church of modest size but of some aesthetic accomplishment. Their self-similarity suggests strongly that a canonical view had emerged of the 'correct' form of a church in Ireland and that this had already become so iconic of 'The Church' in Ireland that it was represented in all the available media; stone, vellum and metal and no doubt in wood also, although examples have not survived.

The iconic status of the wooden church is perversely confirmed by Bede's excoriation of the use of wooden churches by the Irish and those influenced by Irish monasticism (Sherley-Price 1968, 190-192). Bede does not conceal his intention to demonstrate the transcendence of the emerging Roman version of catholicism as the 'real' Christianity and thereby to enhance the claims of York against Canterbury to the primacy of England's kingdoms with centralised control exercised via a national network of bishops in dioceses. Rome's fear of the intellectual independence and economic strength of the large western monasteries required their eclipse but the acknowledged sanctity of their founders and their early successor abbots and abbesses, and the veneration in which they were held locally and abroad did not make this an easy task. Bede damned these 'men' with the faint praise he places in the mouth of Wilfred:

'So I do not deny that they were true servants of God and dear to Him, and that they loved Him in primitive simplicity but in devout sincerity.' (Sherley-Price 1968; 191)

Thus, also damning the canon of the Irish church, its saints, scholars, calendrics, tonsure, institutions and the modest structures that had come to symbolise them.

Whatever the details of its above-ground form and ornamentation, it is clear from the early literature that a complete church could be specified by a single dimension and thus, Hilary Murray cites Cogitosus's record of St Patrick ordering the construction of a church of 15 feet, 'that is 15 ft long and 10 ft wide' (Murray 1979), whilst elsewhere in the text the Saint calls for the construction of 'a church of 19 ft'.

This implies the use of a 'modulus-plus-ruleset' approach to architecture, like that in Book IV of Vitruvius on the proportions of temples (Vitruvius 2009).

Simple rectangular churches in stone were built contemporaneously with the wooden churches of Ireland and continued to be built after the introduction of the Romanesque in the first quarter of the 12<sup>th</sup> century. Their existence is often only revealed in excavation or when conservation works involve removal of later accretions. These 'shoebox' churches<sup>28</sup> somewhat muddy the clear water of the canonicity of the wooden churches and their simulacra. However, the simplest structures have probably always been more common than the iconic forms, especially as the influence of 'The Church' was consolidated and as the shift to diocesan organisation eclipsed the power of the monasteries, even in Ireland and created a demand for parochial churches.

It is important to note that neither the canonical nor the iconic are necessarily the only, nor even the most common forms of their time although preservation bias plays a part in creating the opposite impression. Barral i Altet has observed, for example, that in the 87 year period of the reigns of Charlemagne and his son Louis the Pious, some 30 cathedrals, 400 monastic institutions and 100 royal residences were built, of which only a handful survive (Barral i Altet 1998; 11). Unsurprisingly, the more canonical and more iconic structures have preferentially survived and the quotidian have been more generally lost. Survival bias therefore tends to operate in favour of the iconic and the canonical.

## **The Muddle of the Romanesque**

Larkin's suggestion that many modern English novels have a beginning, a muddle and an end, can be contrasted with which the scholarly construct of the Romanesque which rather begins with a muddle and muddles through to its end. The structures called 'Romanesque' exhibit strongly regionalised characteristics throughout Europe.

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<sup>28</sup> Scaled-up in the post-reformation, these became an ascendant anti-style, the 'post-reformation barn' churches which only slowly yielded to the aggrandisements of architecture, other than under the local privileged patronage of the great and good.

Each describes a real world phenomenon, i.e. a group of structures whose collective identities are based upon observations of shared characteristics of high repeatability. In this sense, it is not merely a mnemosaic categorisation, *contra* O'Keeffe, who argues that some scholars treat the Romanesque;

as a sort of historical *fait accompli* rather than as a construct invented two hundred years ago (O'Keeffe 2007, 51).

O'Keeffe further suggests that;

any of the questions that we ask of Romanesque material may be embodied not in the actual material itself but in our characterisation of it as Romanesque. (O'Keeffe 2007; 55).

Zarnecki noted that the chronological limits of the developed Romanesque cannot be unambiguously defined (Zarnecki 1989) a problem in part created by its regional differentiation and its often imperceptible beginnings sometime between the early 10<sup>th</sup> and 11<sup>th</sup> centuries (Ferne 1983; 73). It also yielded to the Gothic over a transitional period, with regional variation in the rates of change (Zarnecki, 1989, 5; cited in O'Keeffe 2007, 51) albeit that the Gothic form was rather fully developed in its very first expression at St Denis, commissioned by abbot Suger, and completed in 1144.

Ferne explicitly addressed the real-world/mnemosac issue,

[it] is worthwhile asking if the new style is a convincing historical phenomenon or merely the result of an academic exercise. (Ferne 2006; 295-96)

concluding, *contra* O'Keeffe, that the former is the case.

In his treatment of the real-world and mnemosac issues of the case, O'Keeffe, *inter al*, aligns with and amplifies Zarnecki's 'still-lives' view of the past. Both writers postulate or assume clear boundaries to historical processes, a proposition sometimes

described as ‘scientific’<sup>29</sup>. Perhaps the time is at hand for historical studies to accept Aristotle’s advice and learn to live with the often manifest uncertainty of our subject areas rather than aspire to an unavailable and indeed spurious precision;

-It is the mark of an instructed mind to rest satisfied with that degree of precision which the nature of the subject admits, and not to seek exactness where only an approximation of the truth is possible (Aristotle: Nicomachean Ethics, Book 1, Chapter 3)

Humans experience the past as a continuous process, not as a sequence of isolated snapshots<sup>30</sup> with abrupt boundaries between successive events (or styles). The Romanesque did not abruptly change to the Gothic any more than did the Mesolithic to the Neolithic (Sheridan 2010). In general, ambiguous boundaries with transitional and intermediate forms indicate non-trivial change processes of some duration. Only in the mnemosac can processes be arbitrarily declared to have widespread instantaneous transitions and clear boundaries<sup>31</sup>.

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<sup>29</sup> However, the sciences, even the ‘hard sciences’ value transitional boundaries as indicators of processes of change. Thus, diffuse boundaries, in Soil Science indicate evolution in the soil’s pedogenic profile in situ over time, whilst abrupt boundaries indicate dumping of new deposits at a point in time (Limbrej, S (1975). *Soil science and archaeology*. London, Academic Press.). The 17<sup>th</sup> century’s codification of probabilistic studies (Abrams, W. (2003). "A Brief History of Probability." from <http://www.seconddmoment.org/articles/probability.php>.) and the more recent (1960’s) advent of fuzzy logic and fuzzy maths (see Zadeh, L A (1965). *Fuzzy sets*. [N.Y. and London], Academic Pr. and Ross, T J (2010). *Fuzzy logic with engineering applications* Chichester, U.K., John Wiley. for examples) all highlight the acceptability, indeed the inevitability of constrained imprecision in studies of causes and effects.

<sup>30</sup> Invoking the viewpoint and experience of the observer encourages me to ignore the obvious propositional tautology, viz, all ‘continuous’ cine films are in fact sequences of stills. In addition, some quantum theories can be construed as meaning that because time itself is quantal the continuity claimed here may not be real, however, even if God does play dice, the interval between time-quanta is necessarily too short to allow for human perception of the stills in this ultimate ‘cine reel’ and, on the macro scale of human experience we may ignore this difficulty.

<sup>31</sup> This is perhaps recognised in Thomas’s suggestion that the Mesolithic/Neolithic transition is in part a real world issue and in part a result of changes in the paradigms from within which the two periods are now understood;

‘... the transition from the Mesolithic to the Neolithic coincides with the point at which two different and opposed approaches to prehistory and its teaching meet. The first of these, which dominates the study of the Palaeolithic and Mesolithic periods, is concerned with human behaviour in terms of adaptive responses to environmental pressures. The latter, more common in the Neolithic and later periods, is more likely to consider human beings as purposive subjects, acting in pursuit of socially-defined goals. As a result, the Mesolithic-Neolithic transition represents not merely a change of



In the real world, as defined, the emergence of an architectural style usually, although not always, requires the physical construction of a novel building, itself a process of some duration (St Denis took nine years to 'Gothicize'<sup>32</sup>), and the subsequent building, replacement, or renewal of a sufficiency of others cognate with it, to consolidate its fundamental parameters. Any such construction programme also operates under the normal constraints of need and affordability and thus, the transition to a new style will be necessarily protracted.

Deriving ultimately from standard building forms as old as the Late Classical period, the Romanesque, unlike the Gothic does not have a specific starting date. St Denis, the first Gothic church, its commissioner<sup>33</sup>, abbot Suger, in the words of Bannister Fletcher (ibid) 'had been impressed by, and wished to emulate, Early Christian basilicas in Italy.' Although St Denis was indeed built in the basilica form it is hard to find a credible Italian prototype for it and perhaps the thrust of Bannister's comment may be taken as suggesting that in studying extra-regional churches, Suger was sufficiently freed of the weight of local tradition to allow him to embrace change and, given his wealth and power, meaningfully to champion the novel. Thus, a step change was effected by the champion of a Lamarckian change in church architecture.

The perfection of the tierceron<sup>34</sup> vault among the so called 'crazy vaults' of Lincoln Cathedral (Fletcher 1996, 467) may also have resulted from an individual act of inspiration. It signalled a step change in the purely geometric generation of Gothic

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lifestyle, but also a point at which our perception of the past changes. It is the boundary between two models of man. (Thomas 1988, 59)

<sup>32</sup> Originally referred to as the *Opus Francigenum* or French style, the term 'Gothic' replacing it only in the later Renaissance.

<sup>33</sup> With the construction of the Cathedral at St Denis, 1135-1144, the Gothic was introduced in a very developed form (Fletcher, B (1996). *A History of Architecture (twentieth edition)*. New Delhi, Butterworth Heinemann.: 371-2 & 423-7) by this single construction project and most of its characteristic elements and parameters were established at once.

<sup>34</sup> A tierceron rib is one of the minor or intermediate ribs in Gothic vaulting that spring from the pier on each side of the main diagonal rib and therefore do not pass through the centre of the vault but may terminate at the ridge rib.

forms, breaking with the traditional construction abilities of the masons (Theodossopoulos and Gonzalez-longo 2010). Theodossopoulos and Gonzalez-Longo noted the absence of evidence from the group of major cathedrals around Lincoln and Nottingham for the transmission of simple rule-sets from one construction project to another (ibid, 2). They suggest that the scale of the projects may have been so large, and of such duration, as to effectively preclude the possibility that individual masons could have learned the techniques sufficiently well on one project to have been able to export them to neighbouring projects. This militates against a gradualist Darwinian evolution of the knowledge and points rather to Lamarckian step-wise development based on an individual act of architectural or masonic creative genius which quickly became canonical, at least regionally.

Like the Gothic innovation at St Denis or the initiation of tierceron rib-vaulting and in the absence of credible evolutionary progenitors, the transition to the construction of broch towers was necessarily abrupt<sup>35</sup>. The typologist's pipe-dream of an evolutionary sequence of structures leading to the broch tower faces the same difficulty that the traditional Darwinian evolutionary biologist encounters in explaining the gradualist evolution of complex structures like eyes or birds' wings. Gould's question, 'of what evolutionary use is 5% of a wing?' can be applied to broch towers also, because 5% of a broch is a low circular building, and not a proto-broch tower. Broch towers leaped fully formed from the brow of Zeus.

Whilst the Romanesque real-world/mnemosac dispute is a complex subject, nothing in it excludes the probability that among structures thought to be Romanesque (even if not universally) *there exists a group of structures in the real world that share sufficient architectural and engineering features in common to ensure that they are more similar to each other than to structures outwith the group*<sup>36</sup>. This italicised text

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<sup>35</sup> An earliest broch may eventually be identified but this will require a new absolute-dating method free of the imprecision and the ambiguities of calibration of radiocarbon dates.

<sup>36</sup> In the example considered here, the group is the mnemosac-derived set of 'The Romanesque' the name and concept of which belong in the mnemosac and both are used to categorise structures which, by our test of consistent repeatability under observation, belong in the real world as here defined.

describes a canonical group on the basis of architectural styles and, in this example, it underpins the use of the term ‘Romanesque’ as a mnemosac concept, descriptive of a statistically self-similar group of real-world structures<sup>37</sup>.

The artwork of Nathan Coley (Figure 11) models large, non-utilitarian buildings, with large enclosed volumes, pointed window and door apses, towers, bells and bell towers, orienting (long axis running east-west), differentiation of use along the long axis, east end for ostentatious windows, west for ostentatious doors, altar behind altar rail or rood screen at east end, foyer or narthex or towers or *westwerk* at west, north-south structural symmetry,

transepts, simpler elevations north and south than the east or west, and so on. Despite the wide structural syntax, there exists a sufficiently high degree of self-similarity amongst these structures to ensure that most western Europeans encountering Coley’s work, or the original structures they represent, would immediately identify



**Figure 11 ‘The Lamp of Sacrifice’ a Nathan Coley exhibition of models of 286 Places of Worship, Edinburgh 2004**

each structure as a church. Indeed, their now common alteration for reuse as housing, bars, etc, does not preclude their identification as now modified churches. Churches of whatever architectural style form a categorical group because their canonicity makes them more similar to each other than any of them is to any other type of structure.

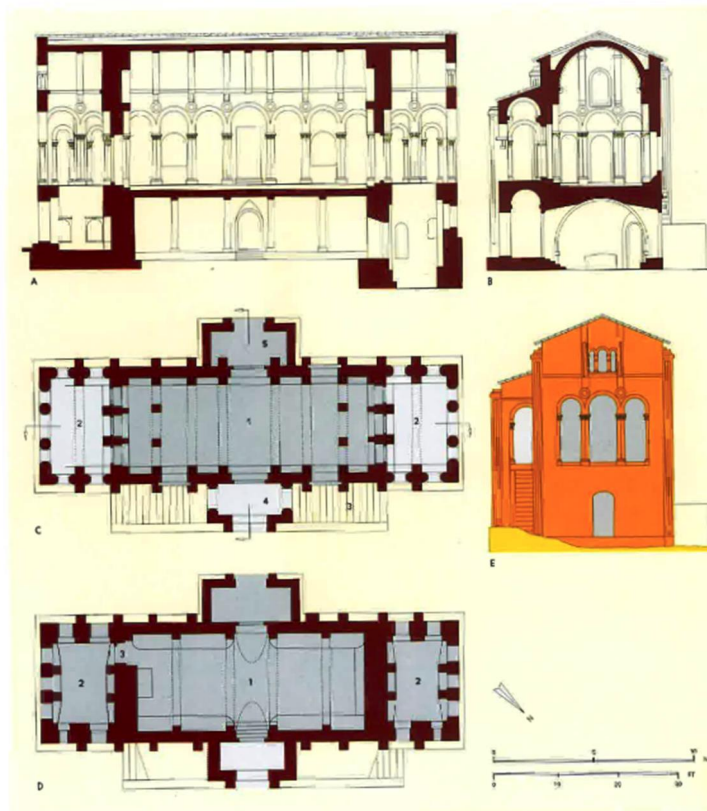
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<sup>37</sup> Thus, Romanesque churches are ‘world 3’ entities in Popper’s terminology (Popper 1978b; his ‘world 2’ encompasses the human intellect).

### Acanonical Asturian pre-Romanesque churches:

The pre-Romanesque churches of Asturias, it is argued here, are acanonical because they fail to qualify as a canonical group in their own right and indeed some of them are not easily recognised as churches in the first instance<sup>38</sup>. These churches are grouped together on the basis of their dates, geographical juxtaposition and known histories; their group identity does not rest on a shared architectural feature-set.

Some of the churches



**Figure 12** The palatine church of Santa Maria de Naranco, after Barral i Altet 1998

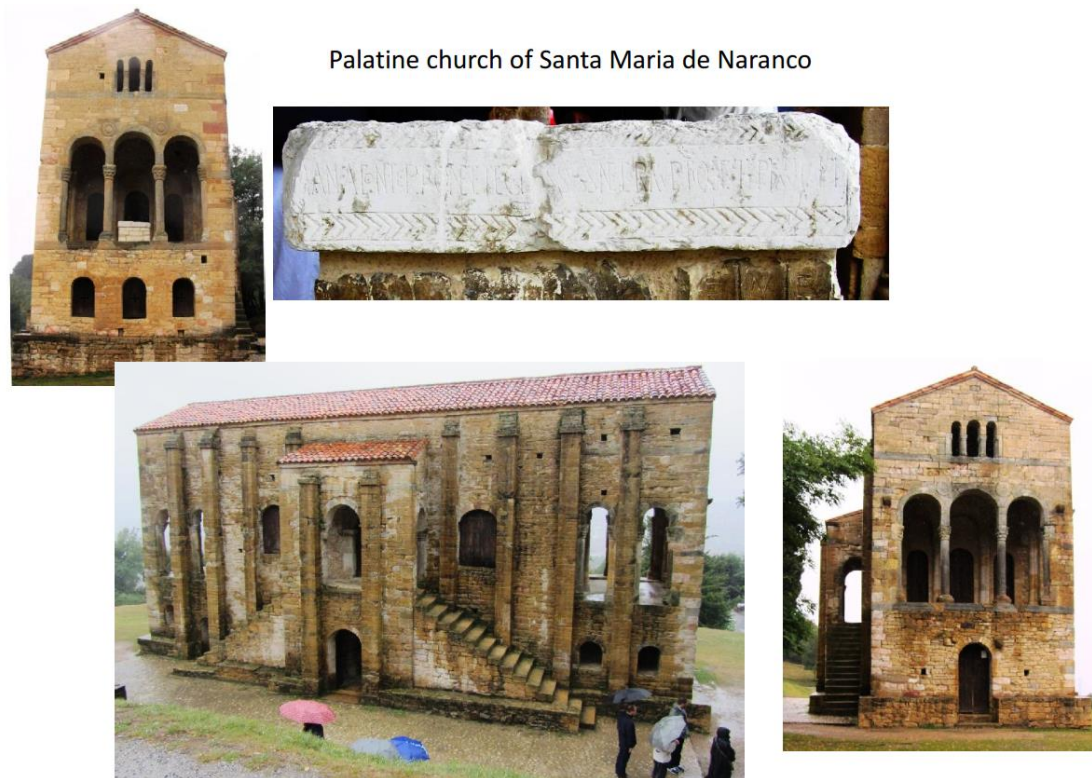
in question are palatine churches which, in the absence of certain specific characteristics, would not easily be identified as churches. Ramiro I and his queen consecrated an existing palace building as a

- A two-storey palace  
Palace-belvedere of Santa María de Naranco, Oviedo, containing an altar that was dedicated to the Virgin Mary on 24 June 848.
- A Longitudinal section  
B Vertical section  
C Plan of the upper storey  
1 The barrel-vaulted main hall  
2 Three-arched side porches open to the exterior
- 3 Access stairways  
4 Entrance porch  
5 Balcony (now ruined)
- D Plan of the ground floor  
1 Vaulted central room  
2 Timber-roofed side rooms
- 3 Door connecting the east side room with the main part of the structure  
E West elevation

<sup>38</sup> The suggestion that their differences could constitute the basis of their grouping is dismissed here because the group of all different objects, being unbounded, is infinite, and thus either not a group at all or one that is logically indistinguishable from the entire cosmos.

church in 848, dedicating it to the Virgin<sup>39</sup>. The dedication of Santa Maria de Naranco as a church is recorded in an inscription on the surviving altar in its east belvedere (Figures 12 and 13).

Its use assumes the general population's observation of services from the slope near the palace hall at Goslar (Conant 1973, 45). The presence of the Santa Maria altar on this first-floor loggia-like setting, obscured from the interior chamber and visible



**Figure 13 Santa Maria de Naranco, northeast elevation (bottom left) with southeast and northwest elevations, above and right. The inscribed southeast edge of the altar is shown above, right.**

only at a distance from outside makes this a very un-church-like liturgical device, albeit that it is a perfectly charming structure. Conant's comparison of this structure with Germanic, Mesopotamian and Saxon antecedents, rather highlights its otherness than finds a plausible ancestry for it (Conant 1973, 46).

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<sup>39</sup> This required the rededication of the nearby basilica named for the Virgin, which was therefore rededicated to San Miguel de Lillo.

The earliest Irish oratories, stone and wood, could not have contained more than a handful of close friends and it has also been argued that the public heard mass and received the sacraments outwith the structures (Leask 1977). The presence of outdoor altars, known as *leachta* (sing. *leacht*) has been noted at several early Irish sites, e.g. Reask (Fanning 1981), Inishmurray (O'Sullivan and Ó'Carragáin 2008, Ó'Carragáin 2010, 251; and see Ó'Carragáin 2010, 187-191 for general comments) and these imply that outdoor devotions probably were common amongst the earliest Christians.

Thus, Ramiro's acanonical church may, with the Irish and Scottish oratories, indicate a deeper unorthodoxy in that the engagement of the laity with services within the body of the Church may not have been an original feature of early liturgical practice in some parts of western Europe.

The rededicated church of San Miguel de Lillo, founded in 848 AD, and just a few



**Figure 14 San Miguel de Lillo, Naranco; surviving fragment. The emergent Asturian cruciform is represented in this church only in the projection of transepts above the line of the side aisles on the exterior. That line was continued into a much larger nave, now lost but represented in cobbling behind the church (visible bottom right in this picture).**

hundred metres from Santa Maria, on the hillside of Naranco, has been described by Barral i Altet as 'a highly compact architecture' (Figure 14), no doubt in part because what survives is the remodelled west end of a larger original structure (Barral i Altet 1998). The footprint of the original basilica with its buttressed nave is

marked out on the ground as a cobbled area behind the truncated chancel and transepts. The church is remarkable for its *transennae* or pierced stone window screens, which became a feature of Asturian pre-Romanesque churches only to be abandoned later.

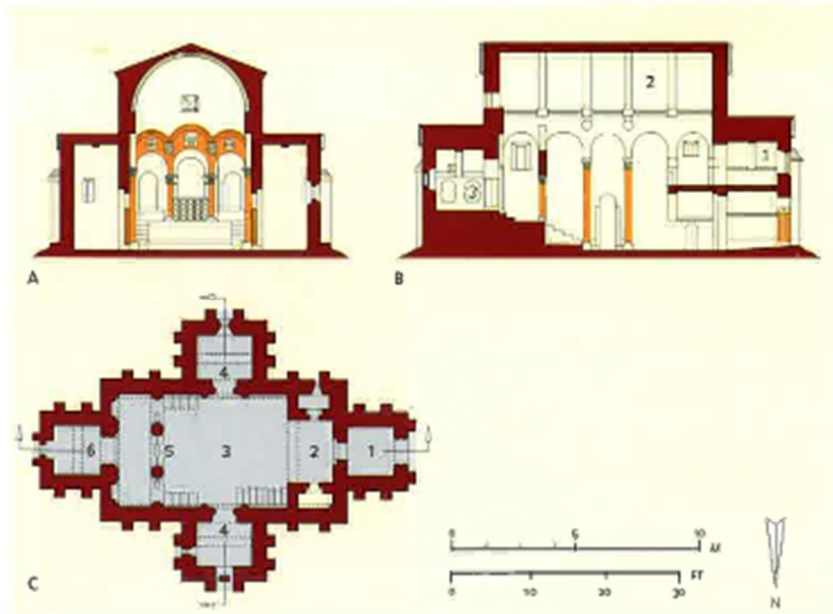
The exquisite church of Santa Cristina de Lena was probably built soon after 905 during the reign of Alfonso the Great. It contains within its tiny footprint a wealth of architectural features suggestive of a desire to cram in every flourish of the church builder's art. It has a raised chancel-like area, in which one might just swing a very small cat, approached via two narrow stairs, north and south, through a chancel screen formed by the insertion of ornamented slabs between two central pillars. The semi-circular arches above the screen carry, above them and slightly inset from the



**Figure 15** Sancta Cristina de Lena. The raised chancel with iconostasis-like arrangement of decorated slabs between pillars (above). The apparent depth of the chancel area is an optical illusion; it is less than 1.5 m deep. The narrow access steps are out of shot to the right and left in this image (see plan below).

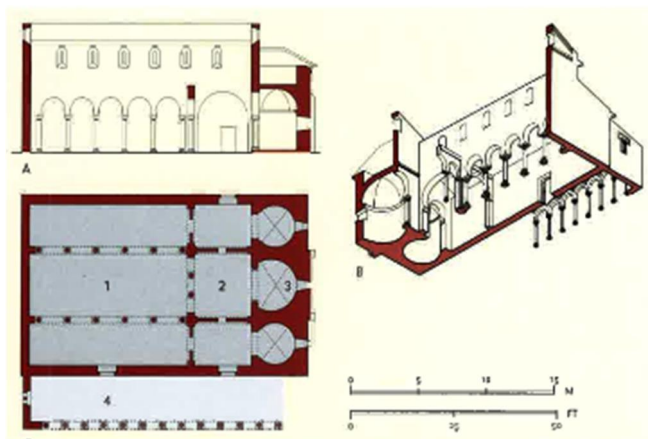
plane of their facade, a second set of three arches atop a low masonry wall into which five *transennae* have been inset. In all but the name, this is an iconostasis and would not seem out of place on the eastern Mediterranean littoral. The inseting of the upper order in the iconostasis and the positioning of the lateral pillars and engaged

pilasters, together with the blind niches either side of the entrance to the apse, form a series of retreating visual planes which creates an optical illusion of depth in the chancel area which is no more than 1.5 m deep in reality (Figure 15 & 16). With its



**Figure 16 Sancta Cristina de Lena (after Barral i'Altet, 2002)**

plan symmetries and precise orienting, this structure is beginning to acquire western European canonical qualities in its external appearance and proportions but the interior is utterly idiosyncratic and so overladen with architectural and structural flourishes as to be almost incapable of use for communal worship.



**Figure 17 San Miguel de la Escalada (after Barral i'Altet, 2002).**

Finally, the church at San Miguel de la Escalada, (Figure 17) introduces a Mozarabic flourish to the Asturian mix. Built in c. 913 to house refugee monks from Cordoba, it



comprises a basic basilica plan in which the  $\text{transept}$  is subdivided by ornamented orthostatic slabs, in line with the internal colonnades and terminating in a tripartite chevet with horseshoe-shaped floor plans. The entrance is from the south side and lies within a side portico whose outer elevation comprises twelve horseshoe-shaped arches of typical Mozarabic form. The internal arcades are similarly horseshoe-shaped atop slender pillars with foliage capitals in the Asturian style, the whole creating a strong impression of delicacy and light, with lighting of the central aisle from an upper clerestory of small windows. Barral i Altet suggests that this structural delicacy necessitated the use of timber roofing (Barral i Altet 1998,212) and the whole is redolent of contemporary mosques.

The external east gable walls of the church proper displays evidence for a history of significant modification with sealed arches, embedded wooden beams and protruding tussing all indicative of a complex constructional history (Figure 18) which was



**Figure 18 Evidence for earlier wall and roof lines surviving in the external face of the east elevation of the church at San Miguel de la Escalada.**

continued into the twelfth century with the construction to the west of a tower and church in an emergent Romanesque style, the internal barrel vaults of which were subsequently cut away; not a task for the faint hearted.

### **Summary**

This necessarily brief and therefore inadequate account of a small sample of the pre-Romanesque Asturian churches highlights their principal structural characteristic which is their idiosyncrasy; each blithely *sui generis*. They present as the work of patrons, architects and masons who probably had seen Mediterranean churches and

Roman remains and who chose the characteristics they particularly liked or felt were most essential to the core characteristics of a church structure, or to some local liturgical need, sometimes regardless of the scale of the monument under build.

Despite their heterogeneity, these churches share some constants, e.g. the forms of the columns, the insertion of stone screens between them, the latter's iconography, the transennae, or fret-worked stone window inserts, and the lurking or emergent cruciform plan, to take the more obvious of them. For the remainder, however, one searches in vain for multiple repetitions of shared characteristics across the group. In consequence, it is argued here, with no particular claim to novelty, that these are acanonical and Conant's comparisons (above) taken in *reductio* serve only to highlight their lack of group identity and of a detectable historical evolution, thereby confirming the absence of canonical form. Church architecture in Asturias is only brought to canonicity with the advent of the Romanesque.

It should be noted in passing that these structures were significantly modified to the forms in which we now observe them and were extended (San Miguel de la Escalada Figure 17) or contracted (San Miguel de Lillo Figure 14), and presumably only abandoned unmodified where their social or liturgical relevance had fallen below some acceptability threshold (Santa Maria de Naranco Figure 13). Their mutability illustrates both the structures' physical capacity for change and the architectural and engineering responses of their builders to social, religious or liturgical pressures requiring change.

## **Mutability; social process and architectural consequences**

The observation of significant masonry alterations may indicate the scale of mutability of the structures in which they occur. Thus stated, the act of observation with good repeatability seems to ground the process in the real world. However, the qualifications in these statements mask some difficulties in dealing with brochs.

No broch survives intact and therefore all have been altered. This while trite, is literally true; universal mutation has arisen even if only from natural decomposition

of the structures over time, accelerated or decelerated by human interventions. This thesis is focussed on the ‘mind of the builders’ and thus on the intentional activities of the brooch builders. While taking cognisance of the universality of structural decomposition over time, its principal focus remains on modifications whose motivation sprang from social contexts, either alone, or in the main<sup>40</sup>. A distinction is therefore drawn between *Repair (including maintenance)*, which is here a response to natural processes of deterioration and *Alteration*, which is a response to altered social choices.

## **Monumentality and Aggrandisement**

As noted above, the word in the form ‘*Monument*’ implies a memorialising function for the structure to which it is applied and *Monumentality*, by extension means the quality of memorialising in a structure. If the intent of the builder was that the honoured memory should not be lost to the ravages of time, the apparent permanence of stone would have appealed and most surviving *a priori Monuments* are stone built. Of course, for prehistoric *Monuments* this observation may be an artefact of survival because organic memorials have simply been lost<sup>41</sup>

The manipulation of memory was as common a procedure in antiquity as it currently is. History is replete with instances of the theft of the credit for the erection of particular monuments. For example, the pharaoh Akhenaten (obit 1336 or 1334 BC) substituted ‘Aten’ for ‘Amun’ on pre-existing monuments, alienating the Priesthood

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<sup>40</sup> This philosophical position might seem to align the study with the proponents of the social construction of technologies, i.e. the SCOT model (see for example Pinch, T J and W E Bijker (1987). *The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. The Social Construction of Technological Systems: New directions in the sociology and history of technology.* W. E. Bijker, T. P. Hughes and T. J. Pinch. Camb Mass, MIT Press. 17-18). However, Pinch’s SCOT model has given rise to a spectrum of approaches ranging from simple acknowledgement of the importance of sociological context, at one terminus to those at the other terminus for whom every detail of a technology is sociologically determined (see Robert Fox’s useful discussion in the introduction to Fox, R (2012). *Technological Change : Methods and Themes in the History of Technology.* Hoboken, Taylor and Francis. 2012). This study strives for a centrist position, but probably inclines to the social acknowledgement end of the spectrum, eschewing the social determinism of the opposite pole.

<sup>41</sup> Similarly, the impermanence of earthen profiles would, like the impermanence of structural timber, have been obvious to the structures’builders, whatever their consciousness of the earth traces such structures would leave for centuries or millennia (Barber & Ntzani 2012).

of Amun by setting out to destroy the Amun belief and cult structure (Kemp 1989, 298). Earlier, Queen/King Hatshepsut (1508 ó 1458 BC) ambitious building programme was suborned by her stepson, Tuthmose III. On being raised to the throne, he stripped her image and cartouche from monuments and her name from the official king-list of Egypt, a practice continued with vigour by his son Amenhotep II (Cline and O'Connor 2009)<sup>42</sup>. The Romans practiced a form of censure, called, *damnatio memoriae* [condemnation of memory] by which the state could excise all



**Figure 19** The subversion of symbols; in Sofia, Bulgaria, a monument to Soviet socialist realism subverted to American pastiche and finally to the status of a graffiti magnet.

reference to, and all monuments of, a citizen who had offended against the city, or its current rulers. It was reserved in practice for members of the elite and for emperors who had incurred the wrath of subsequent emperors or of the Senate. Three emperors received official *damnatio*, Domitian, Publius Septimus Geta and Maximian (Varner and Mussche 2004, 214-5).

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<sup>42</sup> The New York Times correspondent Sarah Bond commented on such ancient examples compared them with a Cairo court decision to remove images of Hosni Mubarak, his wife and family from all public displays, and their names from street names, etc (NYT May 14, 2011); plus ça change, plus c'est la même chose.

A modern equivalent lies in the elision of images of the early Soviet leaders from group photographs as they fell from power or the subversion of Soviet *Monuments* following collapse of the soviet empire (Figure 19). Control of remembering and forgetting was and remains a potent force in the maintenance of the *status quo*, and Varner and Mussche suggest that its practice lay at the core of Roman Cultural Identity. However, the 2012 paradigmatic view of brochs is that they were farm houses, not memorials and thus monuments, not *a priori* Monuments<sup>43</sup>. This implies that massively built structures constitute a class of non-*Monumental* architecture. Non-functional and exaggerated scaling up of some or all of the parameters of a structure relate to issues of aggrandisement. Here the term ‘aggrandisement’ is used to describe the human desire to alter some possession, in an attempt to improve an individual’s social status by publicly displaying possession of the means to create the ‘biggest’ object of social desirability at the time in question.

Aggrandisement, especially self-aggrandisement, is a characteristic of species in which sexual dimorphism favours the males with larger mass or gaudier raiment. The behaviour of, for example, birds of paradise (Guilford and Dawkins 1991, Irestedt, Jønsson *et al.* 2009) provides a highly apposite model for warrior aristocracies, of the type believed by the Romans to persist amongst those they termed ‘Celts’ in general. Self-aggrandisement was very much part of the Iron Age social and cultural ethos. Poseidonios lists the ritual boasting of warriors along with drinking, superstition and human sacrifice as the elements he found distasteful in the Roman version of ‘Celtic’ society (Green 1995, 28). The use of clothing to indicate status in the early medieval period and its subtle uses to demarcate social transitions are exemplified in, for example Crétien de Troyes’ poem of courtly love, *Erec et Enide* (c. 1170 AD; Le Goff 1992; 132-144). Raiment as status indicator is a common motif of Early Medieval Irish literature also. The gaudy baubles of Iron Age warriors find

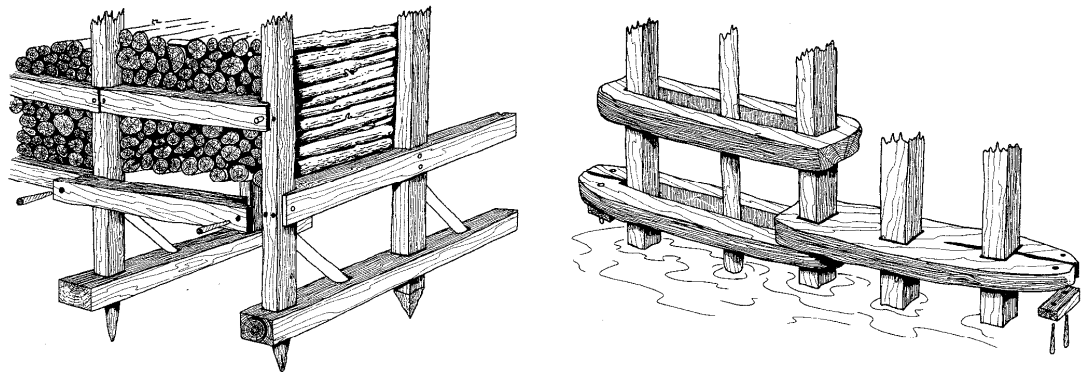
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<sup>43</sup> It may be objected that some of Palladio’s villas, e.g. the Villa Capra, like the Italian Torri and other non-military towers retained a domestic function in their lowest levels and yet are monuments. That is beyond question, but they also were not built as Monuments, *sensu* memorials. Built in conscious aggrandisement of or by their owners, they have now become examples of Riegl’s ‘artistic and historical monuments’ valued for their historicity.

their best modern parallels in modern burlesque, in which irony and humour disable their erstwhile social power.

Greek and Roman scholars commented on peoples they termed ‘Celts’, variously attaching the term to different peoples in different places at different times between c. 500 BC and AD 500 (see Collis 2003, 16-26 for a brief rehearsal of the evidence and Woolf 2014 for a more nuanced account of the classical sources, esp. his Chapter 4). Linguists have used the term ‘Celtic’ to define a group of languages derived from an original Indo-European stem (again, see Collis 2003 Chapter 3 for potted history). Edward Lhuyd introduced into Britain that consciousness of a pan-European language or language group, which his contemporary, Pezron, had just a few years earlier published in France (Lhuyd 1707). Finally, archaeological material, especially metalwork, had revealed the curvilinear style of artwork that has become known as ‘Celtic’ art and its survival into the early medieval period in nations classified by language, classical attribution or common consensus as Celtic, seemed to establish the implicit connection. The archaeological element of the *oeuvre Celtique* is largely confined to the art-historical interpretation of the relevant material remains. Its occurrence on objects from the greater part of western and central Europe has for some unified the linguistic and art historical narratives in a compelling way (Collis 2003, 71-92). Cunliffe, Collis, James, and others, have tried to reconcile the evidential strands of classical citation, material culture and linguistic evidence to identify the ethnic core of what might be termed Celtic, all without measurable success (James 1999, Collis 2003, Cunliffe 2003, James 2012). The challenge they face is that the evidence from one field of enquiry is not commensurable with that from the others, mainly because they do not share a common paradigm. In consequence, the conclusion has become the paradigm and each discipline relies on the others to demonstrate its validity: archaeology relies on linguistics and each on art history, and *vice versa*. In addition, the concept of ethnicity being pursued here has no generally agreed or meaningful definition even in modern studies. Benedict Anderson’s widely accepted suggestion that ‘nationality’ originated in South America and, in corollary, did not evolve in western Europe, should have warned against the simplistic pursuit of a Celtic nation, or super-national entity, in

archaeological studies (Anderson 2016). It is risible to pretend that a modest set of remains derived from an area extending from Ireland to Turkey and from Italy to the Baltic littoral and enduring for over a millennium can identify an underlying ethnicity so coherent that the single term ‘Celtic’ can embrace it all. In his 1997 Antiquity paper, Collis’ response to the Megaw’s book of the previous year initiated the modern debate in the context of a well-reasoned argument that archaeologists should focus on the field evidence and build up from that as good a model for the ethnicity of the peoples involved as the evidence allowed, rather than rely on art historical or protohistoric narratives: it is a pity that the discussion did not close off at that point (Megaw and Megaw 1996, Collis 1997) or follow the multi-layered and socially-contextualised approaches of scholars of archaeology-and-identity (see for examples, Díaz-Andreu 2005, Graves-Brown, Jones *et al.* 1996)<sup>44</sup>.

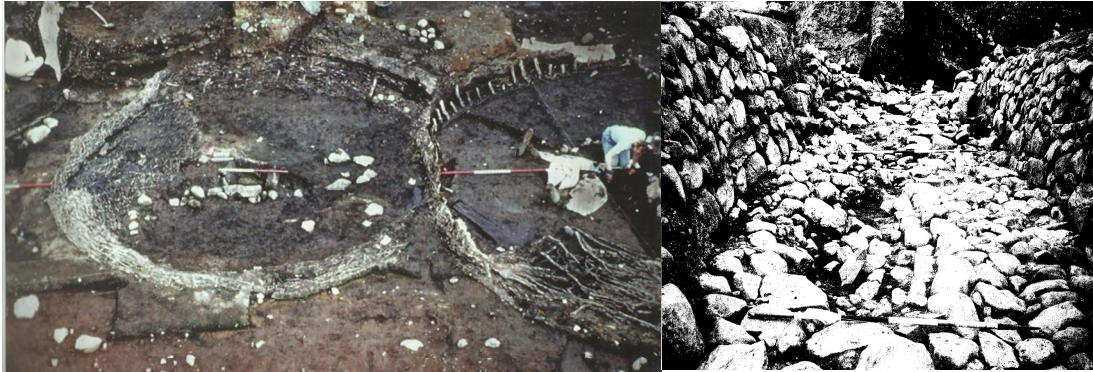


**Figure 20** Reconstruction drawings of the walkway outside the palisade (left) and the use of wooden links to form a ring-beam at the base of the palisade at Buiston crannog, Ayrshire (after Crone 2000 Figures 81 & 82).

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<sup>44</sup> I have ignored the issue of emergent nationalisms of the eighteenth century and their deployment of a ‘Celtic’ notion in support of those nationalisms, just as I have also ignored the innocence of most British writers of awareness of the biases they inherit from their colonialist past. Both factors leaven the stodgy dough of the ‘Celtic’ debate but do little to enlighten; the reader might with profit compare the writings of James with those of Anderson.

Crannogs are wooden palisaded dwelling houses built on wholly or partly artificial islands near the edge of a lake (Morrison 1985). Modern excavations reveal that the palisades of Early Historic examples may have been of considerable complexity,



**Figure 21 Deer Park Farms raised rath; contrasting the double walled wicker house in the interior (left) with the stone lined and paved access ramp (right); after Lynn and McDowell 2011, their Figures 7.5 (left) and 7.1.**

with, for example, large wooden links used to form ring-beams resisting the lateral thrust of the unconsolidated substrate (see Crone 2000, 31; her Figure 22, and here, Figure 20). Conversely, the enclosed circular houses were of modest size, structurally simple, intermittently occupied and frequently foetid (Crone 2000, 99 & 110). Clearly, the exterior presentation of the crannog far exceeded its internal arrangements in technical execution and aesthetic appeal. This is a form of aggrandisement.

The Irish Early Medieval raised-rath at Deer Park Farms (Lynn and McDowell 2011) was, in Phase 6 of a complex settlement sequence, stone-lined at the entrance and had rather dramatic, stone-paved access roads to the top of the truncated cone of the raised-rath (Figure 21, right), on which stood small houses made of mud-plastered, woven withies, shaped like large inverted baskets (Figure 21, left). Again, the disproportion of the appearance and quality of the external façade and the internal housing is abundantly clear.

In these examples the aggrandisement is restricted to, or most developed in, the perimeter façade and access ramps of the entrance area. The engineering and



architecture of the domestic house and its ancillary buildings was modest and the simple structures<sup>45</sup> that, whilst adequately wind and weather tight and no doubt adequately comfortable to live in, make no pretensions to grandeur.

Neither crannogs nor raised raths are considered to be memorialising *Monuments* by the scholars working on them nor are they cited as *Monumental* by others. Cavers, in describing Scottish crannogs, predicates on them a role in veneration of watery contexts (Cavers 2010; 49). However, he goes on to note;

-The association of ritual activity with *mundane* structures with primary functions other than for ritual purposes is known from much of earlier Iron Age Britain (Cavers 2010, 50; italicised emphasis added by this writer)

He does not therefore claim any *Monumentalisation* of crannogs in the service of religious observance. He also notes the mutability of these monuments, albeit that the requirement for alteration had more to do with processes of natural decay and collapse of structures than with social whim (ibid 73). However, explaining the non-functional nature of constructing an artificial island and building a settlement on it Cavers makes the following observation,

-it seems the motivation may rather have been to create a sense of exclusivity while simultaneously establishing presence. (Cavers 2010;169).

This is cognate with the description of aggrandisement, as used here. In writing about crannogs as monuments, Cavers is clearly using the term in its colloquial sense and not as a descriptor of a memorialising *Monument*.

Stout has argued that multivallate raths (or ringforts) were the residences of higher status individuals than the occupants of univallate raths in early medieval Ireland (Stout 1997; 96-7) and Lynn has argued for the use of raised raths by high status

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<sup>45</sup> Perhaps not quite so simple, in fact. The reconstruction of the Deerpark roundhouse type at Navan visitor park, documented by Lynn and McDowell 2011, 593-602, has been a demonstrable failure and despite the use of additional post props to keep it aloft, its roof continues to deform, spiralling down and sagging inwards. Its current (2016) form is charmingly akin to a storybook witch's house.

residents also (Lynn 2011; 573). However, neither of them has suggested that these structures, entailing many hundreds, or even thousands of tonnes of earth-moving, are memorialising *Monuments*. These were settlement structures, capable of the sophisticated expression of social status perhaps, but certainly not constructed as *Monuments a priori*. Their civil engineering requirements are at least as substantial as those involved in broch building when considered in tonnages moved, operations on water, the challenge of bulk transport and the person-days required to complete the structures. The absolute scale of these structures and their construction costs in terms of committed resources and in opportunity-cost terms are not less than the costs of building a broch<sup>46</sup>. Clearly not *a priori Monuments*, their decay to ill-defined mounds has excluded them also from the status of monuments *a posteriori*.

Sufficient has been set out here to make the case that aggrandisement was a prominent feature of the Iron Age cultural landscapes of Ireland and Scotland at every level from the purely personal strutting of young men, and no doubt women also, to the construction of monuments whose elaborated facades concealed the potential for squalor within. As noted above, domestic structural architecture was restricted to the hut circle and roundhouse for more than 2000 years prior to the brochs and continued long after the latter's demise. The broch tower was a radical departure from the rather banal roundhouse, and did not mimic the latter's regional variability; a trait expected of vernacular building (see Social demand; vernacular or polite CHAPTER 4). It is postulated that a period of relatively settled social conditions preceded broch building in which male aggression was channelled by display behaviour in language, ornamentation, dress and feasting. Towards the end of the period, progressive aggrandisement of the external presentation of their structures became a norm. Finally, the idea of building towers emerged as part of and against a

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<sup>46</sup> Opportunity cost is expressed as the value that would have accrued from the use of the deployed resources in some other way. Also defined as; a benefit, profit, or value of something that must be given up to acquire or achieve something else. Every resource (land, money, time, etc.) can be put to alternative uses, every action, choice, or decision has an associated opportunity cost (after <http://www.businessdictionary.com/definition/opportunity-cost.html>).

background of aggrandising behaviour. Apart from being taller, the broch tower did not materially differ from the quotidian roundhouse and brochs enclose footprint areas no larger than those of many simple roundhouses. There are no obvious technical innovations in broch towers that materially alter the human experience of roundhouse-life and broch towers introduced many difficulties, including roofing, acquisition of water and provision of sanitation and drainage. Its main contribution must therefore have been its external profile which commands attention but at a high price. On balance, it is therefore proposed that broch towers were more likely to have been aggrandised monuments than memorialising *Monuments*.

### ***Monumentality, aggrandisement, canonicity and mutability***

An *a priori Monument* is inherently unlikely to be constructively modified once built and during the period of its tectonic relevance. Exceptions occur, for example when a *Monument* is made more permanent (as with Lenin's tomb) relatively soon after its construction. However, a *Monument* may also be altered when it is captured within a new social context, as for example when Christian crosses were mounted on or carved into the tops of Neolithic menhirs in Brittany<sup>47</sup> or when churches were built on Neolithic chambered cairns like La Hougue Bie (Patton, Rodwell *et al.* 1999).

Conversely, where a structure was erected to aggrandise the commissioning agent, it is rather more likely that the agent's replacement, heir or conqueror, would in fact redesign or rebuild in self-aggrandisement of that successor<sup>48</sup>. Indeed, further alterations within the lifespan of the builder may be triggered if changes in status or significant new achievements inspire architectural expression within the constructed medium. Thus, we may hypothesize a level of correlation between memorialising

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<sup>47</sup>These interventions, and many others like them may have been inspired by provisions of the Theodosian Code of AD 438, Mohen, J-P (2002). *Standing Stones. Stonehenge, Carnac and the world of megaliths*. London, Thames and Hudson.)

<sup>48</sup> This has been noted above in respect of the rebranding of Hatshepsut's buildings by her successors.

*Monuments* and standardising canonicity, on the one hand, and between aggrandisement and mutability on the other.

Life is untidy and humans generally somewhat less than consistent so the boundary between canonical and mutating behaviours is not an abrupt one. Rather, the results of striving for *Monumentality* or for aggrandisement bleed over into each other resulting in monuments that can occupy more than one of the four domains of the 2x2 relationship matrix illustrated above (Table 2.2). LCMs are altered and can also

**Table 2.2 Relationships between *monumentality*/aggrandisement and**

	<b>Monumentality</b>	<b>Aggrandisement</b>
<b>Canonicity</b>	<i>Monuments</i> Tombs & Cenotaphs Palaces Churches	<i>monuments</i> Quotidian and idiosyncratic Vernacular buildings Hut circles
<b>Mutability</b>	Restricted to repairs and conservation	Repaired and Altered in primary use and Refashioned in secondary reuse

occupy different domains at different times. The first domain contains canonical *Monumental* structures like tombs and cenotaphs, palaces and churches. If the brochs prove highly canonical, they could fall into this category for the early part of their existence. The second domain, moving clockwise, contains canonically aggrandised structures, e.g. elaborate vernacular structures like the mud towers of the Yemen or the Italian *torri* or Scottish crannogs. In the third domain,

aggrandisement is present but overwritten by mutation over time, and many brochs fall into this category for the later part of their biographies. In the fourth domain, the counter intuitive *Monumental* but mutable category holds sway, residential or functional wings in castles converted to Renaissance palaces, on the cheap, like that at Stirling Castle, provide exemplars.

## Tectonics

Although the term 'Tectonics' is widely used in architecture<sup>49</sup> it is an elusive concept and one not always defined by its users. Its association with terms like 'poetic' (Frampton and Cava 1995), 'vision' (Beim 2004) and 'art' 'picturesque' or 'romantic' (Boddy 1999) implies that tectonics relate to the mnemosac dimensions of the real world buildings. Robert Maulden provides the following description:

'Tectonics in architecture is defined as "the science or art of construction, both in relation to use and artistic design." It refers not just to the "activity of making the materially requisite construction that answers certain needs, but rather to the activity that raises this construction to an art form." It is concerned with the modelling of material to bring the material into presence: from the physical into the meta-physical world' (Maulden 1986, 3)

Maulden argues that its tectonic scheme invites consideration of the structure in its own right, not merely as a sign or signifier. Tectonics relates also to the 'sociology' of the structure, to the ways in which its existence facilitates social interactions and practices and in which they are moulded by it. He finds his exploration of the real world entity of a structure within the framework of Heidegger's 'fourfold' conceit<sup>50</sup> (Heidegger 1970) which provides a metaphor for Maulden, emphasising in turn, and *inter alia*, the setting of the structure, as a material consideration of its material existence in addition to the tectonics of its configuration (Maulden 1986, 29).

Broch tectonics therefore concern themselves with the structural arrangements of the broch tower in its articulation with its occupants and setting, and *via* that setting with the larger landform. The monument-containing landforms, interacting with human

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<sup>49</sup> A search of Google in May 2015 revealed 315 architecture books in print that include the word in their titles.

<sup>50</sup> Heidegger used the ideas of earth, sky, divinities and mortals to contextualise elements of his thinking, thus, for example, humanity is earthbound under a physical sky with conceptual horizons and in interaction with divinities, etc. If the reader detects something of Nazi mythologies in this it may be because Heidegger was a Nazi supporter and while he may not have promulgated the inanity of their pseudo-mythologies, his work very probably influenced them.

perception, have created landscapes ever since, some of which may have been cultural landscapes.

## Paradigmatic constraints

In epistemology and science, a paradigm is a set of concepts or patterns of thought which can comprise theories, hypotheses, methodologies and ways of thinking, and postulates and standards for what constitutes legitimate contributions to the subject area in the opinion of the subject area's current elites. It is a loose structure that often contains untested, indeed unchallenged assumptions.

-Kuhn suggests that certain scientific works, such as Newton's *Principia* or John Dalton's *New System of Chemical Philosophy* (1808), provide an open-ended resource: a framework of concepts, results, and procedures within which subsequent work is structured. Normal science proceeds within such a framework or paradigm. A paradigm does not impose a rigid or mechanical approach, but can be taken more or less creatively and flexibly. (Blackburn 2008)

Kuhn also suggested that paradigms may arise from

"i universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of practitioners. (Kuhn 2012).

It is argued here that paradigms;

- frame what is to be observed and analysed
- identify the kind of questions that should be asked and influence how these questions are structured
- identify what predictions may be made in the primary theory of the discipline
- determine the appropriate methodologies and
- determine how the results are to be interpreted,

Evidence is the subset of all available observations that is selected as the basis for determining an issue. Thus, it is clear that paradigmatic assumptions can influence the basis on which they are selected.

It is argued here that whatever their differences in point of detail and principle, the principal protagonists in the broch debate Armit, Harding and Mackie share a common paradigm which is discussed in detail below. Focussing down onto broch towers alone from within that paradigm, Chapter 3 considers a Revised Standard Model of the broch tower that remains by and large consistent with their several views i.e. is conceivable from within the paradigm of these authorities and of course it should be because it is based on their writings. What falls outside the prevailing paradigm is the conception of broch towers as canonical structures.

## Taxonomy

Classification, esp. in relation to its general laws or principles; that department of science, or of a particular science or subject, which consists in or relates to classification. (OED 1979)

Variouly described as the processes of description, identification, nomenclature, and classification of things, taxonomy is given rigor by the logic of the criteria deployed to distinguish between one set of things and another. In the 17<sup>th</sup> and 18<sup>th</sup> centuries, taxonomical studies of nature focussed on the organisation of sets of plants and animals, living and dead, on the basis of their observable attributes (see for examples, Morton 1981). These were *attribute-taxonomies*, sets of types, based on their observable attributes.

Darwin, noting the similarities within sets of organisms and the distinctions between them, created the theory of evolution as an explanation of the bounded heterogeneity of living organisms (Darwin 1859). He transformed the taxonomic categories from inert assemblages to stages in the process of evolution. In consequence, membership of a set within the evolutionary scheme implicitly furnished precise information on the members of that set and on their interrelationships with all of the other sets within the taxonomy. Nine years later Mendeleev's periodic table achieved the same

transition from endless attribute-typologies of reactions and compounds<sup>51</sup> to a categorisation of elements whose positions in the periodic table predicted their characteristic reactions and compounds and furthermore identified gaps between the known elements into which hitherto unidentified elements must fit. These are *process-taxonomies*, sets of objects that form the nodes<sup>52</sup> in a phylogeny<sup>53</sup> of the developing products of some defined process.

All taxonomy is reductive, even where it simply lists sets of self-similar entities. Where the organisation of the taxonomy reveals deeper realities governing the members of the taxonomic dataset, it is even more reductive and in and of itself, becomes an interpretative mechanism that both encapsulates extant interpretations and is capable of generating new interpretations. Process-taxonomies have the capacity to generate testable predictions, a feature that is absent from attribute-taxonomies.

No evidence exists, in natural evolution or in chemistry that a *bestø* state exists towards which the processes of change are directed. Directed change is a matter for belief, faith or religion where the resultant categorisation is formulated in terms of rules that originate outside of the dataset. Categorisations formed by axioms that originate outwith the dataset are termed here *axiomatic-taxonomies*.

The development of simple copper and bronze flat axes during the Early, Middle and Late Bronze Ages is said to progressively expand the cutting edge and over time to add hammered-up side flanges, to facilitate hafting, and the flanges, developing in

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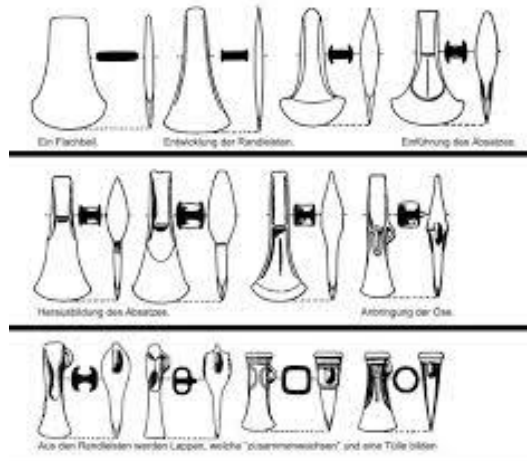
<sup>51</sup> Mendeleev wrote his *magnum opus* (*Principles of Chemistry*: two volumes, 1868&1870) initially as a categorisation of reaction types and products and the periodic table arose from his observation of patterning in the reactions of elements when ordered by atomic weight.

<sup>52</sup> The nodes are the sets as previously identified and considered as nodes, fixed points within the branching network that represents the evolutionary process.

<sup>53</sup> Phylogeny; noun, plural: phylogenies. (1) The evolutionary history of a taxonomic group of organisms. (2) The evolutionary development of a species or of a taxonomic group of organisms. (3) The history of development of a tribe or racial group. (Biology online: [http://www.biology-online.org/dictionary/Phylogeny\\_06\\_01\\_15](http://www.biology-online.org/dictionary/Phylogeny_06_01_15))



turn, become larger and, finally, joined with a stopping ridge across the axe face, are folded over into closed pockets (making a palstave; second from left in lower row of Figure 22), again to facilitate hafting. Finally, a complete redesign in the Late Bronze Age introduced the optimised socketed axe; efficiently hafted and with close to optimal metal-weight to cutting-edge-length ratio.



**Figure 22 A typology of Bronze Age axe types (after Montelius). From top left to bottom right, this sequence of axe types in copper and bronze illustrates development under three constraints; to minimise metal use, maximise cutting edge length and optimise for hafting security. The socketed axes, lower pair on right, break from the developmental trend with different design and greatly optimised performance in all three criteria.**

Axes do not breed, producing variation in their fertile offspring in an environment that winnows out all but the fittest who preferentially survive to reproduce while others fall by the wayside. Instead, advances in metallurgy and production technology provided the variations and fitness-for-purpose weighed against economy-of-material-use provided the winnowing. Thus, in the case of Bronze Age axes, the process taxonomy can be said to characterise development that achieves at each technological stage optimisation of the object in terms of fitness-for-purpose and economy of production. Although the mechanisms of change, improved design and economy of production, are progressive cognitive innovations based on perception, memory, judgment, and reasoning, the end product is a process-taxonomy of the type called, in archaeology, a *typology*<sup>54</sup>.

<sup>54</sup> This is an example of the interaction of Popper's World 1, the physical world, interacting with his World 2, his mental or psychological world, and generating World 3 typologies, which are products of the human mind (Popper, K (1978a). *Three Worlds: The Tanner Lecture on Human Values*, University of Michigan., 143).

The intervention of these cognitive processes in artefact<sup>55</sup> development can ensure that the development is directed. There may not be a best animal, no master of all creation, but there is certainly, at any given instant a best available axe, the one that offers the best optimised balance between fitness for use and economy of production. Artefact development can be gradual, as in the case of the flat axe-to-palstave sequence described above, but can also display abrupt change, as in the case of the socketed LBA axes, when cognitive interventions independent of the development processes drive a step change in design. Biological evolution is not directed but developmental trends in anthropic artefacts most certainly can be directed. Natural evolution is Darwinian, i.e. undirected, but development in anthropic products can be Lamarckian<sup>56</sup> because user experience, practitioner skill and technological advances can significantly alter or even substitute for the next generation of artefacts produced.

In Darwinian evolutionary systems, fitness for the prevailing natural environment constrains endless variation. Humanity forms a dynamic part, often the most dynamic part, of its own environments. However, prior investment in the prevailing infrastructure of production, ranging from practitioner skills to tooling and technological knowledge in Lamarckian systems, constrain frivolous and random variation. In addition, if an artefact answers a specific and quite singular practical need, as an axe does, the required functional outcome also constrains the scope for idiosyncratic variation<sup>57</sup>. There is a momentum in design and an inertia in design-products, that together constrain the scope for random idiosyncratic change. The environment constrains the forms and building materials and the sociological context

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<sup>55</sup> By artefact here is meant any object made by human beings, regardless of age, material or scale and thus including micro-, and trace-remains, on the one hand, and major structures on the other.

<sup>56</sup> Lamarck argued that it was possible for organisms to inherit acquired traits, a view which the Darwinists dismissed (Lamarck, J B P A d M d (1914). *Zoological philosophy : an exposition with regard to the natural history of animals*. New York ; London, Hafner.).

<sup>57</sup> Idiosyncratic axes exist, albeit in very small numbers. Examples of highly ornamented axes or examples too large or too small for functional use exist in almost all periods. Archaeologists tend to interpret them as -ritual objects, a special category for artefacts that cannot be attributed to a functional use and a term that has no explanatory power.

of localised skillsets can consolidate on a standard or liberate creativity and enable the emergence of local variants and regional styles (see Social demand; vernacular or  $\neq$ polite $\emptyset$ ).

Historians of technology are content that;

$\neq$ Technology forms part of a seamless web of society, politics and economics $\emptyset$ (Pinch, 1996 , 21)

However, events, post industrial revolution, suggest that relevant emergent technological capacities can also be the initiators of change in that web itself and examples abound from the social impacts of the development of the contraceptive pill to the profound socio-economic impacts of the internet, altering social, economic and political environments in turn.

### **Taxonomies of brochs (sensu lato)**

Gordon Childe created the category of all drystone built Iron Age monuments, which he called the  $\neq$ castle complex $\emptyset$  because of their shared structural properties; all of them were stone built, and all seemed to him to be defensive in character (Childe 1935). In creating this set, he relied on these two criteria, one observational and *real-world*, and the other conceptual, and for his time, also paradigmatic and even zeitgeistic in that it founded on late colonial perceptions of the interrelationships between peoples and places within the colonial gavotte<sup>58</sup>. His was clearly an axiomatic set even though the axiom was an unstated paradigmatic colonialist predisposition.

In the 19<sup>th</sup> and early 20<sup>th</sup> century scholarship concerned itself with the seriation of large dry stone built structures in attribute taxonomies (see, for example, RCAHMS 1928, xxxvii; or Graham 1948). In the absence of clear Scottish antecedent forms and consistent with the prevailing paradigm, it was assumed that they were introduced to Scotland by invaders or migrants. Anderson dismissed the once current belief that the

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<sup>58</sup> Ironically, Childe as a Marxist, interned during WWII, would no doubt have found colonialism and its views of peoples and places quite repugnant.

brochs derived from Sardinian Nuraghi because although externally similar<sup>59</sup> neither possesses the characteristic internal arrangements of the other<sup>60</sup> (Anderson 1883; 193).

With the waning of the *Invasion Hypothesis*<sup>61</sup> MacKie suggested that the Scottish Iron Age was influenced from the south of England, by the arrival thence of information and knowledge or from the actual arrival of small numbers of refugees fleeing the Belgic incursions in the first century BC (MacKie 1965). Harding, amongst others, has been sceptical about the inference MacKie has drawn from historical sources, not least because there is no direct historical evidence for this flight of refugees (Harding 2004, 120). However, he rejects it mainly because he cannot accept that people who in their homeland had never built in stone would, following a mass migration, suddenly construct the most elaborate stone built monuments in Britain's prehistory:

-Quite why a tradition of monumental building in stone should have been catalysed by colonisation of refugees from a region hardly noted archaeologically for its roundhouse building tradition, and certainly not in stone, remains an enigma.ø (Harding 2004, 120)

Harding also rejects the D-shaped semi-brochs identified by MacKie as pre-broch-tower evolutionary steps, arguing that these are the remains of brochs, parts of which have been lost to marine or other erosion (Harding 2004, 120-1). This point is moot in the absence of sufficient excavation to determine the issue either way. It is

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<sup>59</sup> Both are truncated cones in form, albeit that vastly more complex forms of Nuraghi also exist.

<sup>60</sup> A somewhat more nuanced comparison is provided in Barber, J, G Cavers, A Heald and D Theodossopoulos (2013). Memory in practice and the practice of memory in Caithness, NE Scotland, and in Sardinia Cambridge University. A copy is appended at Appendix Memory.

<sup>61</sup> The Invasion Hypothesis proposes that all or virtually all major socio-cultural changes detectable in the archaeological record were caused by the invasion of masses of people. It was a popular concept in the colonial era, which in Britain extended to the 1960s, when archaeologists and perhaps the population in general believed they had current exemplars before them.

assumed for the purposes of this thesis that semi-brochs are not broch towers and they are not considered further<sup>62</sup>.

MacKie's historical inference constrains the initiation date for broch and broch-cognate monuments. Chronology is a critical element in the proposed development process (see discussion in Chapter 5

Building Chronologies), so its constraint makes MacKie's typology an axiomatic taxonomy because while the monuments classes are based on attributes their phylogeny is critically constrained by an individual inferential axiom drawn from outwith the groups' attributes.

MacKie's 1965 paper has remained the basis of his analyses of brochs ever since (see his recent publications for relevant discussions and comprehensive bibliographies, MacKie 2007a, MacKie 2008, MacKie 2010). Only 5 of the almost 600 known or probable brochs provide direct evidence for the existence of a high hollow-walled tower, but he has identified categories of proxy evidence for the erstwhile existence of broch towers on some 80 monuments in total (MacKie 1965, 103). His 2002 criteria for the definition of a broch were set out in his corpus volume (MacKie 2002, 2) and they comprise a circular plan, thick wall, large size, a scarcement and possession of at least one of an upper gallery, chamber over the entrance, stacked voids in inner wallface and an intra-mural stair. The monuments that meet these criteria are set out in Table 2.1, below.

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<sup>62</sup> However, work on Dun Grugaig suggests that this semi-broch may have been a full broch tower and an account is appended in Appendix Small Sites

**Table 2.1 Euan MacKie's listing of multi-storey brochs with some additions. Tower and Broch numbers refer to the project database, which will be made publicly accessible in the NMRS. Visited means visited specifically for this study (In *Appendix Small Sites* the NMRS codes for these brochs are listed).**

Tower Number	Broch Number	Site Name/s	Semi-Brochs	Visited	Scanned
<b>OUTER HEBRIDES</b>					
5	110	LEWIS, TRAIGH NA BERIE		*	
27	574	LEWIS, LOCH BARAVAT, DUN BARAVAT			
33	572	LEWIS, DUN CARLOWAY		*	
48	576	NORTH UIST, DUN AN STICIR		*	
51	491	NORTH UIST, LOCH AN DUIN, DUN TORCUILL			
53	575	SOUTH UIST, BORINISH, DUN VULAN			
67	63	LEWIS, BRAGAR, LOCH AN DUNA			
<b>WEST COAST &amp; INNER ISLES</b>					
ARGYLL					
42	586	DUN MHUILIG			
MULL					
2	538	AN SEAN CHAISTEAL, ARDNACROSS, MULL			
3	587	AN SEAN DUN, MULL			
24	585	DUN AISGAIN, MULL			
37	536	DUN NAN GALL, MULL			
29	547	ISLAY, DUN BHORARAIG			
SKYE					
26	500	DUN ARKAIG			
32	490	DUN BORRAFIACH			
34	481	DUN COLBOST		*	
38	580	DUN GRUGAIG 1	*		
39	579	DUN GRUGAIG 2		*	
40	488	DUN HALLIN		*	
44	480	DUN OSDALE		*	
45	581	DUN RINGILL	*	*	
47	493	DUN SLEADALE			
49	577	DUN SULADALE		*	
74	578	RUDH' AN DUNAIN	*		
28	496	DUN BEAG, STRUANMORE		*	
31	582	DUN BORODALE, Raasay			
TIREE					

Tower Number	Broch Number	Site Name/s	Semi-Brochs	Visited	Scanned
76	583	BARRA HEAD LIGHTHOUSE, Bernera	*		
43	584	DUN MOR VAUL		*	
<b>NORTHERN ISLES</b>					
SHETLAND					
8	266	BURRA NESS, Yell			
9	27	BURRALAND		*	
19	178	CLICKIMIN		*	
20	589	CLICKHIMIN BLOCKHOUSE	*?		
21	22	CULSWICK		*	
55	16	BROUGH HEAD		*	
59	224	HOLM OF COPISTER, Yell			
60	3	HOUBIE			
66	571	LEVENWICK		*	
69	26	MOUSA		*	
71	203	SUMBURGH AIRPORT		*	
80	192	JARLSHOFF		*	
ORKNEY					
6	182	BROCH OF BORWICK		*	
10	418	EAST BURRAY		*	
11	83	HILLOCK OF BURROUGHSTON, Shapinsay			
58	34	GURNESS		*	*
61	7	INGSHOWE			
64	108	WESTRAY, KNOWE OF BURRISTAE			
68	174	MIDHOWE Rousay		*	*
70	68	NEWARK Sanday			
73	268	BROCH OF REDLAND			
<b>NORTH MAINLAND</b>					
CAITHNESS					
7	385	BURGH RUADH			
15	463	CAIRN MERK			
23	411	DUNBEATH		*	
63	138	KNOCK GLASS			
72	302	OUSDALE BURN			
78	441	WATENAN			
79	440	YARROWS		*	
ROSS & CROMARTY					
12	511	CAISTEAL GRUAGAIG		*	
25	532	DUN ALASCAIG			
46	588	DUN AT RHIROY	*		
SUTHERLAND					

Tower Number	Broch Number	Site Name/s	Semi-Brochs	Visited	Scanned
1	327	ALLT NA MEIRLE			
4	290	BACKIES			
13	128	CARN BRAN		*	
14	289	CARN LIATH		*	
16	143	CARROL			
17	309	CAISTEAL NA COILLE			
18	85	CLACHTOLL		*	*
22	57	DAIL LANGWELL			
35	112	DUN CREAGACH			
36	58	DUN DORNAIGIL		*	*
41	314	DUN MHAIGH			
54	305	EAST KINNAULD			
56	297	FERANACH			
57	113	GRUMMORE			
62	325	KINTRADWELL		*	
65	123	LANGDALE			
75	287	SALLACHADH		*	*
INVERNESS					
50	509	DUN TELVE		*	
52	508	DUN TRODDAN		*	
STIRLING					
77	553	TORWOOR, TAPPOCH BROCH		*	
<b>NEWLY IDENTIFIED TOWERS</b>					
ORKNEY					
81	591	THE CAIRNS		*	
CAITHNESS					
82	435	THRUMSTER MAINS		*	*
83	296	ALLTBREAC		*	*
84	361	KEISS BROCH		*	*

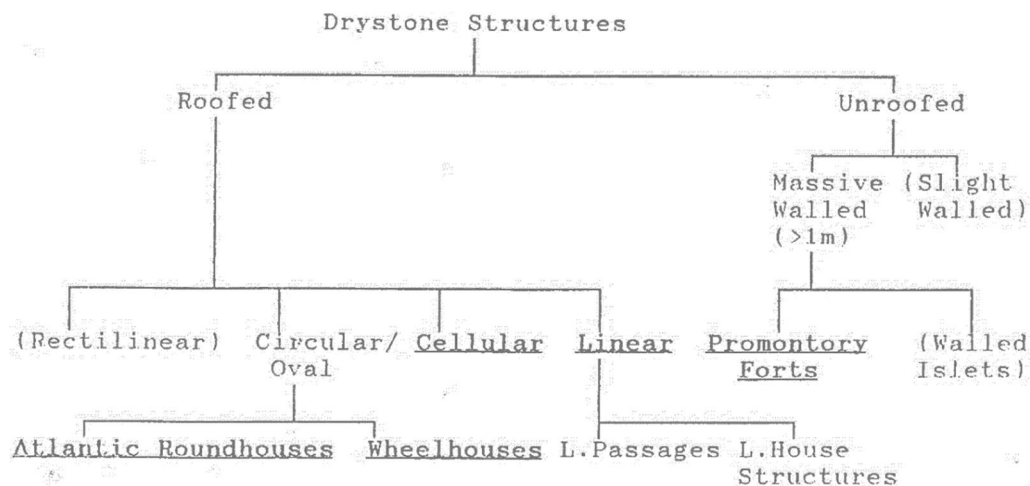
Ian Armit, in his 1990 PhD study (published in extract as Armit 1992; see esp. 16-18), critiqued MacKie's 1965 paper, whilst acknowledging its continuing relevance and influence in broch studies. Armit united all massively drystone-walled structures within a single category of 'monumental architecture' arguing that their size and massing are their core defining characteristics. His regrouping of the known



monument types initially dealt with drystone-built Iron Age monuments in the Hebrides, but his *schema* has come to be applied throughout Scotland (ibid III 4.1, 19). Armit suggests that:

-í The present system is designed purely as a research tool. It is not assumed that these categories have meaning other than as a convenient means of defining structurally-related monument forms.ø(ibid 18)

Armitø was thus not intended to be a process taxonomy, merely a rearrangement of the profusion of existing monument types under more convenient headings (Armit 2005a, 7; reproduced below as Figure 23). In addition, no process that would lead to a phytological arrangement of the sets was proposed. Thus, for example, the positioning of individual categories of monument in his dendrogram conveys no information on their interrelationships, especially on their chronological relationships.



**Figure 23 The Armit axiomatic taxonomy (from Armit 1992,19)**

Neither was it an attribute taxonomy because the attributes for membership of the various sets were not defined. Writing about the Atlantic Roundhouses alone, Armit suggests that:

-The Atlantic roundhouse terminology is a system for classification and description. It need not imply any particular evolution of structural forms. There is no assumption, for example that complex roundhouses need

have existed before broch towers could be built. (Armit 2005a, 9 and see also his Figure 1)

The Armit taxonomy is best viewed as an axiomatic taxonomy because it is predicated, as he suggests, on the axiom that it should assist the study of the material; it is a device to assist discussion of the material. The categories exist, only in compliance with the rule that they should assist study, a clear axiom.

Unfortunately, other scholars have attributed a phylogenetic character to his axiomatic taxonomy. The Iron Age Panel of the Scottish Iron Age Research Framework (ScARF), for example report:

Some regions (notably Orkney) appear to show a typologically clear developmental sequence from fairly simple, though sometimes substantial, roundhouses (Figure 5 Armit (e.g. Early Iron Age structures at Bu, Quanterness, Calf of Eday, Pierowall Quarry, Howe), through increasing architectural complexity (including intramural chambers & galleries, upper staircases, inner wall-face voids, scarcement ledges) to broch towers. (ScARF 2010)

The ScARF panel report suggests that Simple Atlantic Roundhouses (SARs) develop to become Complex Atlantic Roundhouses (CARs) and then brochs and finally broch towers. They suggest, in terms, that broch towers evolve in a Darwinian fashion. However, the excavated evidence and emerging patterns of radiocarbon dates do not support this sequence.

## The MacKie and Armit axiomatic taxonomies

Much of the recent debate in broch studies has focussed on MacKie's typology of monuments and the rejection of all or significant parts of it by Armit, Harding and others. MacKie's clear criteria for inclusion in the broch tower category are set out in Chapter 3. Harding is rather dismissive of typological preoccupations (see for example, his comment on Hamilton, in Harding 2004, 130), and he relaxes MacKie's criteria, so that, *inter al*, brochs may, in Harding's view, be oval<sup>63</sup> (Harding 2004,

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<sup>63</sup> Touching on Armit's taxonomy of Atlantic Roundhouses in the Hebrides, Harding similarly dismisses one of Armit's discriminants, arguing that it is not possible to identify the roofability of

108). The development process proposed by MacKie suggests that their origin, once the impetus to build them had been imported from the south, lay in the west for the whole complex of broch-cognate monuments (MacKie 1965). Building began with the semi-brochs, a local variant, evolved to broch towers, diffused locally quite rapidly, and spread east and north, to return later in a reflux movement which is necessary to account for northern characteristics in some western broch towers, like those at Glenelg. There is negligible evidential support for this hypothesis.

### **Of lacunae in time and space**

The profound difficulty of dating brochs will be discussed in somewhat more detail elsewhere (see Chapter 5 and Appendix Thrumster) but given the chronological significance attributed to existing typologies, it is appropriate to note here that taxonomies are usually either designed, or assumed, to scale for time. This is certainly true for process taxonomies which, without chronologies, would not represent phylogenies. Armit has been clear that his axiomatic taxonomy of drystone built structures is expressly not phylogenetic, (above and Armit 1992, 18). Childe grouped Scottish drystone built structures into a single class, the castle complex, in the absence of any real chronological evidence for their further subdivision. The view that all of these monuments, being drystone built, must necessarily represent a single coherent cultural phenomenon persists. It has, by extension, facilitated the emergence of the assumption that all of the deposits on broch sites are the products of a coherent socio-politico-cultural process; an assumption that remains essentially unchallenged.

In the taxonomic discussions outlined above, the entities being compared in the literature were in general floor plans. MacKie alone of the protagonists routinely

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monuments unambiguously, and goes on to redefine some subgroups in the taxonomy (Harding, D W (2004). *The Iron Age in northern Britain : Celts and Romans, natives and invaders*. London Routledge. P 130.

concerns himself with the third dimension, but even then, the three-dimensionality of the monuments forms no major part of his hypothesis. Whilst buildings archaeologists are clear headed on the solid forms of later buildings, there is an equally clear and somewhat bizarre absence of discussion on the form and massing of brochs and their upper structural remains. That they are mainly ruinous may explain the reticence to engage with the subject but the most striking specific difference between broch towers, on the one hand and on the other broch-cognates, especially the Simple and Complex Atlantic Roundhouses (SARs and CARs) is the fact that broch towers are towers.

It may reasonably be hypothesized that the reason why we have failed to categorise these monuments is that they do not share sufficient attributes to be capable of categorisation. They fail to show a meaningful taxonomic phylogeny because they have no shared phylogenesis. They simply did not develop one from another or if they did, this remains to be demonstrated. The ScARF suggestion (above) that SARs develop into CARs and CARs into brochs and thence into towers is unsupported by the available evidence and apparently unsupported by the creator of the taxonomy. The available evidence does not exclude the possibility that SARs were built in the terminal Bronze Age and Earliest Iron Age, the brochs in the 4th Century BC and that the CARs overlapped the brochs and continued in use thereafter, possibly into the early medieval period.

Brochs and broch-cognate monuments do not form typologies. This situation might be altered if the chronological resolution of radiocarbon dating, even when supported by Bayesian analyses, were somehow to improve dramatically. However, even then, chrono-sequencing, the creation of an axiomatic-typology of the basis of the chronological axiom, viz, that all monuments falling into the same (axiomatically) defined age bracket forms a coherent cultural group lacks logical rigor. The idea that successive categories defined on the basis of date alone must necessarily form a developmental sequence would be simple teleology.

In addition, the evolution of a complex form like a broch tower cannot be achieved stepwise; 5% of a tower is about as much use as 5% of an eye or a wing. The

essence of a tower is that it emerges instantly, without stepwise predecessors and thus would always prove hard to set into a structural typology. These complex difficulties contributed to the selection of broch towers alone as the subject matter of this thesis.

## Chapter 3 The broch: an archaeo-architectural background

### Introduction

Chapter 2 set out the general framework for this study, introducing brochs (Figure 24), the structures under consideration in this thesis, and the paradigmatic context of their study. The builders of Scottish Broch Towers were constrained by instinctual, evolutionary, ethological, social, physiological and philosophical limits and the structure was further constrained by physical parameters including building technology, engineering competence and access to the necessary material and human resources. In the aggregate, these constraints define the territory within which the mind of the builder was enabled to define, commission and build realisable structures in any period but this study addresses their influences on decision making in the Scottish Iron Age.

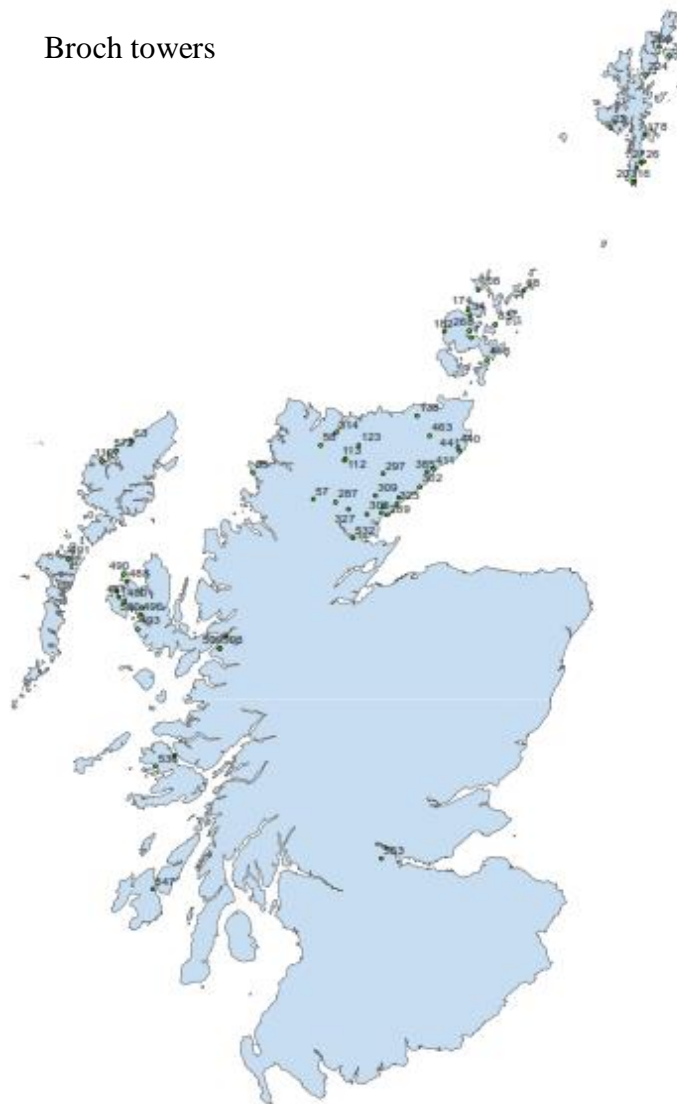


**Figure 24** Glenelg brochs, Dun Telve interior on the left and Dun Troddan, exterior, on the right.

In this chapter, the Standard Model of 2012, i.e. SM 2012, summarises the lowest common denominator view of the broch tower at the initiation of this study and critically reviews the extant literature, to present the Revised Standard Model (RSM) in the context of which the mind of the builder is considered. The RSM was the starting point for the understanding of broch towers and is drawn from, and constrained by the paradigm of its time. While most of its characteristics are based on MacKie and Armit, they disagree with each other on important points while some of their shared views, for example, their belief that brochs are not vernacular builds are not generally accepted. SM2012 does not, therefore reflect all the views of any one author.

## A historiography of brochs

Broch towers (Figure 24) are uniquely Scottish Iron Age structures, possibly built and rebuilt within the interval 400 BC and AD 400<sup>64</sup>, and reused in a variety of roles thereafter. Broch towers occur over much of Scotland (Figure 25) but are concentrated in the northeast mainland, Orkney, Shetland, the Hebrides and the adjacent Atlantic coast of Scotland.



**Figure 25 The distribution of towers.**

Other relatively massive stone structures were built in the Scottish Iron Age Period, especially on the west coast, and the term ðbrochø was and is still sometimes applied to all of them but in this study the term ðbrochø will refer only to broch towers, unless an alternative meaning is stipulated. The zeitgeistic view, which is a lowest common denominator rather than a consensus, largely follows Armit and MacKie, who disagree on several key issues both

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<sup>64</sup> Several chronologies persist, mainly divided between ðShortø and ðLongø forms; the former favours early initiation and the latter a late initiation not earlier than 200 BC. The cited limits encapsulate both and the matter will be discussed further anon.

with each other and with the LCD view<sup>65</sup>. The LCD view of SM2012 unifies the disparate group of Scottish massively-built drystone structures in terms of their perceived 'monumentality' (Armit 1992), which, as discussed in Chapter 2, is interpreted here as 'aggrandisement'. Armit renamed the group of all stone built monuments 'Atlantic Roundhouses' and has evolved the axiomatic-taxonomy of the members of this group (discussed in Chapter 2).

It is currently conceived that brochs were a wholly Scottish development albeit that discussion continues about their place of initiation within Scotland. Childe and Hamilton argued for the area of their greatest concentration (Caithness and Orkney) as their place of origin (Childe 1935, 204; Hamilton 1962, 82). MacKie argues for an initiation in the West and South (MacKie 1965, 124), in part on the basis of their 'fit-to-landscape' i.e. these are small forts evolved in a highly differentiated landscape, not major forts that, like the hillforts, command wider plains. He also founds on the presence in the West of what he believes are an evolutionary step towards brochs, the semi-brochs (MacKie 1991).

Several recent publications have reviewed, in whole or part, the history of broch studies and their place in wider Iron Age discourses, thus relieving the writer of the need to repeat that Sisyphean, but oddly meretricious task (Gilmour 2000, MacKie 2002, Henderson 2007, MacKie 2007a, MacKie 2008, Harding 2009a, MacKie 2010, Romankiewicz 2011).

Prior to the 1900s, the taxonomic interrelationships of the apparent profusion of broch-like structures inspired a great deal of interest, as did their relationships with other monument types like the duns of Argyllshire. The earliest comprehensive classification was that reported by the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) in their inventory of the monuments of the Western Isles (RCAHMS 1928; xxxiii óxl), under the general heading of

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<sup>65</sup> Armit varies from the lowest common denominator views of SM2012 arguing that brochs were not a vernacular build, a view he shares with MacKie,



Defensive Structures. It should be noted that issues of invasion, of defence and of attack dominated the interpretational paradigms of the period, and indeed continue to influence later discussions. Even now, in rejection, this Colonialist Paradigm remains on the agenda and successive writers feel the need to reject its central tenet, viz, that cultural change is only brought about by conquest. In the 1960s the concept of transmission of ideas became accepted as an alternative to the need for large-scale population movements to explain the arrival of new cultural packages. Now, the pendulum having swung, the rejection of any possibility of folk movements is absolute, despite abundant historical evidence for its occasional occurrence<sup>66</sup>. Following an hiatus in taxonomic development, Sir Lindsay Scott proposed the separation of wheelhouses<sup>67</sup> from the class of generic brochs and the division of wheelhouses into two sub-classes (Scott 1947). Euan MacKie, in his 1965 study of the brochs set out his fundamental categorisation of brochs (MacKie 1965). He focussed on clarifying the definition of the broch, *sensu* 'broch tower' and would only include in this category brochs with the characteristic hollow wall construction at or above ground level. In addition, he notes that brochs are also truly circular or very nearly so (MacKie 1965, 103). Mackie accepts that only a small proportion of the almost 600 known examples provide direct evidence for the existence of a high circular hollow wall but he has identified certain categories of proxy evidence for its erstwhile existence. Thus, MacKie's criteria for the definition of a broch tower may be set out as:

- i) Existence above the ground floor of a drystone built tower with characteristic complex wall structure; or proxy evidence for same;
- ii) Surviving evidence for at least one upper gallery:
- iii) The existence of a weight relieving void or gap over a door lintel (i.e. 'stacked voids');

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<sup>66</sup> Like the Helvetian failed migration to southwest Gaul in 58 BC that acted as the *causus belli* for Caesar's campaigns in Gaul (Commentarii de Bello Gallico Book 1, Chapters 2-29).

<sup>67</sup> Circular houses within which radial subdivision of the circumvallate annulus and clear central space, with or without a hearth, create the appearance of a spoked wheel in plan.

- iv) Massive ground floor wall, sufficiently thick to reduce the diameter of the enclosed garth to 40% to 65% of the external diameter;
- v) True circularity of ground plan

Armit in general accepts MacKie's definition of the characteristics of a broch tower (MacKie 1965), including the structures here called supra-entrance stacked voids, like that at Loch na Beirgh (Harding and Gilmour 2000) but perhaps more dramatically exemplified in the Glenelg brochs (see Chapter 7). Writing in 2003, however, Armit adopted the suggestions of John Hope that the stacked voids are built to allow warm air from the interior to enter and dry the cavity, i.e. the inter mural void. This proposal does not explain their preferential construction at points of greatest weakness in the structure, at the main and stairway entrances, where the compression forces are too strong for the available lintel material. Similarly, Hope (in Armit 2003, 73) expresses the view that the incorporation of the intermural wall void was made 'despite the structural risks involved', implying that a solid wall would have been a safer construction. However, infilling or building into the volume occupied by the gallery would simply extend the footprint of the overloaded mass, creating a rather more unstable monument, and it would increase the costs of quarrying, transport and building by almost a third.

Whilst he does not restate them, MacKie (ibid) refers to Angus Graham's comments on Scott's 1947 paper in which he, Graham, rejected Scott's argument for three classes of broch; Class I being 5 to 8 ft high, Class II perhaps up to 15 ft high and the very small Class II containing the five known broch towers to which he adds, not without reservation, the monuments at Culswick and Burraness (Scott 1947; 35-6). Instead, Graham (1948) argued that the simple possession of a massively thick wall is sufficient grounds for conjecturing a tall tower.

Graham (ibid) also supported the idea that the circularity of brochs was important, noting that of the 132 measured monuments, only 6 showed variations between the maximum and minimum internal diameters that equalled or exceeded 6% of the diameter. His Table VIII indicates a national average of 9.75 m for internal diameters of brochs, of which 6% would amount to roughly 59 cm. If this, not inconsiderable

variation from circularity represents the precision of build, the criterion of circularity would be severely challenged.

MacKie's 1965 paper has remained the basis of his analyses of brochs ever since (see his recent publications for relevant discussions and comprehensive bibliographies (MacKie 2007a, MacKie 2008, MacKie 2010). Ian Armit, in his PhD study (published in extract as Armit 1992; 16-18), critiqued MacKie's 1965 paper, whilst acknowledging its continuing relevance and influence in broch studies.

The implication, from ScARF and others that Simple Atlantic Roundhouses (SARs) evolve to Complex Atlantic Roundhouses (CARs) and these evolve to broch towers has been noted and rejected in Chapter 2, mainly because the excavated evidence and emerging patterns of radiocarbon dates do not support this simple sequence. Table 3.1 (after Lowe 1998) lists radiocarbon dates from SARs, which when calibrated, indicate dates in the range 985 BC to 370 BC. Each radiocarbon date represents a single event, i.e. the death of the carbon-bearing organism, and is attributable to a single year. All of the 13 relevant dates could fall on the first year of this interval or the last or any date between, or could be spread more or less evenly over the interval. Thus, they could predate CARs and Brochs or be coeval with them. The poor chronological resolution of the calibrated dates is caused by the Hallstatt Plateau<sup>68</sup>. Thus, while SARs may predate brochs, on these dates alone, they could equally be contemporary with them. The ScARF proposal is not supported by the evidence, or rather, can only be supported if a rather particular reading of the evidence is selected.

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<sup>68</sup> Radiocarbon determinations are calibrated to give a better fit to calendar years by the use of a calibration curve. When the curve forms a plateau i.e. runs closer to parallel with the X-axis, it is hard to resolve individual dates from each other. The Hallstatt Plateau calibrates dates in the first millennium BC to very wide spans, typically of somewhat more than four centuries (see Reimer, P J, M G L Baillie, E Bard and e al (2004). "IntCal104 terrestrial Radiocarbon age calibration, 0-16 Cal Kyr BP." *Radiocarbon* 46(3): 1029-1058.

, Bronk Ramsey, C (2005). The OxCal Radiocarbon calibration Software, version 3.10. or Dockrill, S J, Z Outram and C M Batt (2006). "Time and place: a new chronology for the origin of the broch based on the scientific dating programme at the Old Scatness Broch, Shetland." *Proc Soc Antiq Scot* 136(89-100), 98 for details).

The Complex Roundhouse class comprises Atlantic Roundhouses that display some of the architectural features associated with broch towers and includes, Dun Bharabhat (Harding and Dixon 2000), Broch I at the Howe (Smith 1994) and potentially Jarlshof (Hamilton 1962) as well as Crosskirk (Fairhurst 1984). The case for seeing these as non-brochs is rather ambiguous. Certainly, Dun Bharabhat and Broch 1 at The Howe as well as Jarlshof could be argued to be broch towers, on the available evidence. Crosskirk may not be a broch, but evidence now eroding out of the wall, at the cliff edge, could be interpreted as indicative of an intramural gallery, thus promoting its claim to being a broch; further erosion or excavation may clarify this matter.

**Table 3.1 Radiocarbon dates for Simple Atlantic Roundhouses (SARs) (after Lowe 1998). The calibration was prepared by Dalland, based on the Belfast calibration curve (Pearson 1986) and the ranges within which the calendrical date is thought to lie at c. 95% probability equate with the conventional two sigma spread. The Lab Nos suffixed with 'c' have been adjusted for the marine reservoir effect using the (-405±45) estimate, not the modern calibration formulae.**

Monument	Uncalibrated determination, bp	Calibrated range BC	Dated material
Bu (Hedges 1987)			
GU 1228 primary occupation of roundhouse	2470±95	830x385	<i>Salix charcoal</i>
GU 1154 primary occupation of roundhouse	2460±80	810x390	Large mammal bones
Quanterness (Renfrew 1979)			
Q1456 primary occupation of roundhouse	2570±85	915x465	Soil organic matter
Q1464 primary occupation of roundhouse	2440±85	810x380	soil organic matter
Tofts Ness, Sanday (Dockrill SJ) Later deposits in 2ndry roundhouse			
GU 2207 Later deposits in 2ndry roundhouse	2510±140	895x370	<i>Bos</i> bone
GU 2208 Later deposits in 2ndry roundhouse	2470±50	805x410	<i>Bos</i> bone
GU 2544 Later deposits in 2ndry roundhouse	2470±50	805x411	peat

Monument	Uncalibrated determination, bp	Calibrated range BC	Dated material
St Boniface, Papa Westray (Lowe 1998)			
GU 3059c Shell midden TAQ roundhouse	2830±50	800x390	Winkle shell
GU 3291c Shell midden TAQ roundhouse	2850±50	800x390	Limpet shell
Pierowall, Westray (Sharples 1984)			
GU 1580 occupation deposit TAQ roundhouse	2510±80	830x395	<i>Bos</i> bone
GU 1581 occupation deposit TAQ roundhouse	2425±60	780x395	<i>Bos</i> bone
Howe Phase 5 (Smith 1994)			
GU 1789 construction of roundhouse rampart	2405±70	800x385	Charcoal
Crosskirk broch Caithness (Fairhurst 1984)			
SRR 266 construction of broch floor (TPQ)	2380±50	770x400	Charcoal

## The structural sub-assemblies of a broch tower

Brochs differ from all other prehistoric structures in Scotland in being tall towers so that dead-loading and the disposition of compressive and, in lintels over opes, tensile loads were necessarily addressed in their construction. While each broch is a single coherent structure it is also an assemblage of several features that serve functional and possibly aesthetic purposes. Whatever about the latter, the former is amenable to analysis. In the following paragraphs the characteristic features of brochs are set out in terms of the views prevailing in 2012 and, in the main, represented in the 2012 Braby illustration<sup>69</sup> (Figure 26Error! Reference source not found.). This illustration,

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<sup>69</sup> Reconstructions, whether 2- or 3-dimensional, are interpretations and an illustration of the lowest common denominator interpretation of the standard model (SM) was prepared by Alan Braby, based on Dun Carloway, and published by Armit, and others, (see Armit 1996, Figure 7.10). It was still current in 2012. A redraft, published in Heald and Barber 2015 retained the main structural features of the first draft.

heavily obscured by internal structures for which, as will be made clear below, there is little or no evidence, represents the Standard Model as understood in 2012 (SM2012)<sup>70</sup> and is a reconciled summary view of all that had been written about brochs before that date. This is revised below in the light of the information available in 2012, and the consequences of the revised standard model, the RSM, are explored.

While some of the standard descriptions and interpretations of these subassemblies have been criticised in Chapter 2 there is no systemic disagreement about the features comprising them, and these are rarely misreported. Their significance is however misunderstood in the extant literature. Thus, it is mainly in the arena of the SM2012, paradigm that the significance of the differences plays out. In this and in the following chapters the first emphasis will be on clear observation of the features or feature-groups surviving remains and the second on their interpretation in the context of a standard original form. The hypothesis that deviations from the expected forms and contexts of the features are not simply idiosyncrasies of a primary build but indications that they have been altered, is tested and the sequence of those alterations constitutes the monument's biography.

### **Entrances**

Some 96 broch entrances preserve at least some of their original characteristic features. The SM2012 entrance was based on these data. The entrance passage, at ground level, may access one or two guardcells, low, lintelled or corbelled cells entered from the side walls of the entrance passage to the broch. In a few cases the garth may also be accessed from a guardcell (e.g. Clachtoll). The entrance passage (Figure 27) is usually furnished with door rebates (aka doorjambs) and bar-holes/receivers for a wooden locking bar that pinned the door, assumed to have been wooden, against the doorjambs, in addition to the guardcell entrances (Fojut 1981;

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<sup>70</sup> The term 'SM2012' refers both to the model as drawn by Braby (Figure 26) and the body of knowledge that underpinned it and the paradigm from within which it was generated. 2012 was selected as the threshold year because it is the year in which the literature review for this thesis was completed.



**Figure 26 Alan Braby's representation of the broch tower founded in the 2012 paradigm.**

MacKie 1991; 150-151; Armit 2003; 55-78; Harding 2004; 109-123). Some brochs have a secondary set of doorjambs, often providing closure in the opposite direction to that of the original. Some seven examples exist of brochs with two entrances and Clickhimin has three. The second entrances at Ness, Keiss Harbour and Yarrows brochs are secondary and so probably are those at Brounaban and Keiss Road and both of the Clickhimin entrances. A stair foot entrance at Freswick Links was noted but is now destroyed. This writer's excavations at Thrumster broch has added a further example of a secondary opening at the stair foot, albeit one that was subsequently sealed off and remodelled as an intramural cell (see Chapter 6 and

Appendix Thrumster). A second additional example is provided by Old Scatness broch, where a secondary entrance had been opened at the stair-foot and

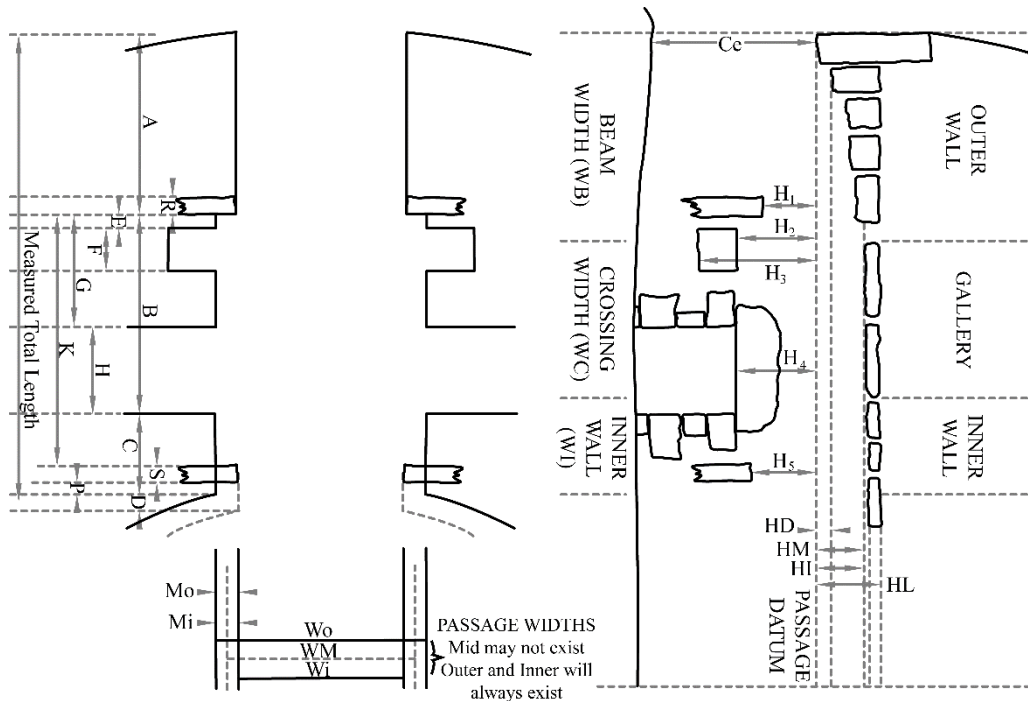


Figure 27 Monument record sheet based on plan and elevation of classic broch

later sealed off again (blocking visible *in situ* in Dockrill, Bond *et al.* 2010, Plate 1.1, and removed by excavation in their Plate 2.5).

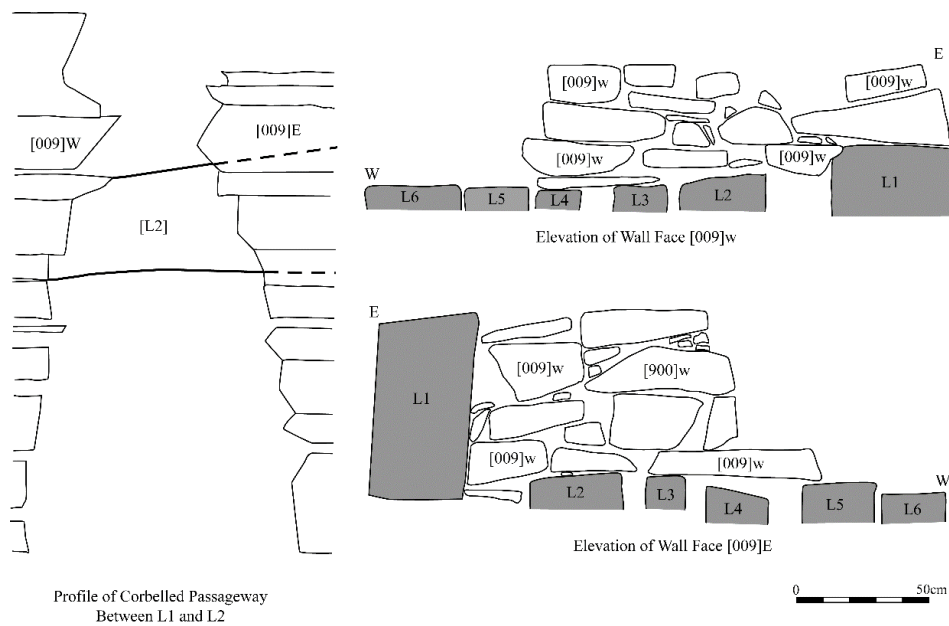
The east entrance at Dun Fhiadhairt, on Skye, is abnormally small (c 0.6 m wide); its apparent height is 0.75 m, but its floor is clearly not fully excavated. It is most probably secondary and related to the division of the floor plan of the broch by a massive if poorly built wall (RCAHMS 1928, 57-70; MacKie 2007b, 813-4). Dun Fhiadhairt is not an example of stair-foot remodelling and it is not impossible that the division of the interior and the formation of such a tiny entrance relate to the use of the structure in sheep husbandry over the past two or three centuries.

Excavations at Clachtoll, Assynt, has revealed the use of a 'composite beam' structure at the outer end of the entrance passage, designed to carry the massive weight of the outer wall across the passage void (Barber Forthcoming b and Appendix Clachtoll). The composite beam consisted of 4 lintels that were particularly massive, one was triangular and the other thinner lintels had been placed



with their longer cross-sectional axis in the vertical plane (Figure 28). An equivalent arrangement of lintels can be seen in Henry Dryden's surveyed sections of Clickhimin, Shetland, drawn in 1865 although observed, their significance has remained unnoticed since then (see detail in Figure 29, below). In his 1865 survey Dryden has illustrated the outer lintels of the entrance passage roof at Mousa as set on one edge (Dryden 1890), presenting their diagonal thickness to the superincumbent mass, and on-site examination confirms his observation.

At several brochs, including Clickhimin, MacKie has identified the existence of a cell-like structure above the outer lintels, but behind an attenuated outer wallface<sup>71</sup>. This is termed here the 'supra-passage cell'. Some 20 of the broch towers retain evidence of these cells, albeit greatly reduced in the main (see Tables 7.3a to 7.3d, Chapter 7). The writer's work at Clachtoll revealed the footings of a supra-passage



**Figure 28** The sides of the entrance passage at the broch of Clachtoll. Note the relative massiveness of lintels L1 to L4 that carry the mass of the outer wall, the latter visible above the lintels.

<sup>71</sup> MacKie includes Clickhimin in this group, and the Dryden section (above) illustrates his point. However, given the scale of modification at Clickhimin, it is perhaps not wise to found on this example.

cell at the outer end of the Clachtoll entrance lintel table, but behind the thick triangular outermost lintel. The supra-passage cell was probably formed by corbelling across the passage and the corbelled structure carried the mass of the core and inner face of the outer wall above the entrance, diverting the stress to the side walls of the entrance. At some brochs, like Mousa and the Glenelg brochs, a development of the cell seems to take the form of a void that extends upwards through the masonry of the outer wall, so that all of the outer wall above the entrance opening may only be one or two stones thick, in effect a curtain wall. However, it should be noted that all of these brochs have undergone conservation works and their current configuration may not be wholly representative of an original state.

Composite beams and supra-passage cells were deployed to relieve the strain on the outer passage lintels of the mass of the thick outer wall. Stacked voids above the inner end of the entrance passage served the same function for the inner wall (below). Together, these features indicate a high level of engineering competence in broch construction and are meaningless adaptations other than in the context of tower building.

### Stacked Voids

As noted above, the inner wall is pierced at the main entrance and the inner wall is also pierced at the entrances to ground level cells, stairways and galleries (see Mousa in Chapter 6 for examples). Above the innermost lintel of the entrance passage and

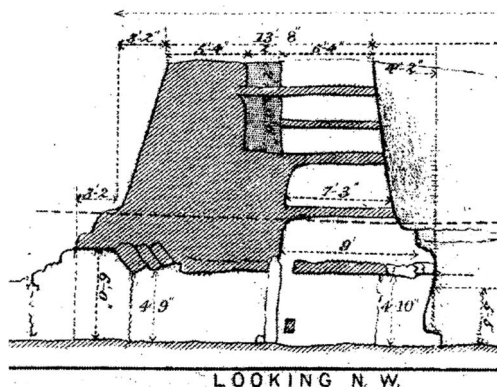
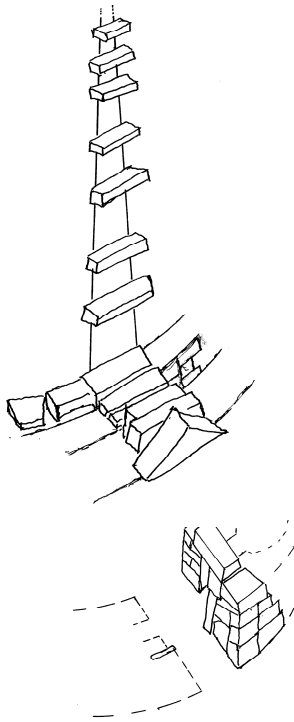


Figure 29 A detail from the Henry Dryden survey of Clickhimin (1865) showing some of the outermost lintels of the entrance passage set on edge, diagonally, to present the greatest thickness of stone to the vertical axis resisting the dead load of the superincumbent wall.

**Figure 30 Sketch of the stacked void and differentiated lintel weight relieving structures at the entrance**



above the lintels of the entrance to the stairway and sometimes also above the lintels of the first floor access doorway<sup>72</sup>, a stacked void gap is built into the inner wall from lintel level to surviving wallhead. The sides of this gap converge with height, at angles in the region of about 10° from the vertical. The gap is spanned by struts, referred to as ‘lintelsø’ in the literature, some level with the intramural gallery floors, others not, and the latter increase in frequency with height. These gaps are termed ‘stacked voids’. Shorter ranges of stacked void sometimes appear over the lintels of cell entrances, e.g. at Mousa (Figure 66) or Dun Carloway<sup>73</sup> (Figure 136).

Isolated stacked voids occur, comprising two or three voids set high in the inner wallface also occur, and these are without a generally accepted interpretation in the SM2012 literature. Armit, *inter al*, has suggested that they serve to provide light into the gallery. However, they are generally set so high that the galleries they access are too narrow to enter. In a 2013 FMSG Seminar, this writer had hypothecated that they may have been placed above the inner wall foot at points in which the presence of intramural structures at ground level reduce to critically low levels the effective footprint over which the weight of the inner wall is carried (Figure 31). The consequent increase in ground loading could thus be raised to potentially destructive levels<sup>74</sup>. This hypothesis was empirically tested<sup>74</sup> by the reconstruction at 1:1 of the

<sup>72</sup> From the first stair landing to the garth interior.

<sup>73</sup> The Dun Carloway examples have been masked by ill-advised modern interventions.

<sup>74</sup> In Chapter 8, the ground loading of a range of brochs is calculated and it is shown that these often approach levels challenging to most soil substrates. Take the internal radius ( $r$ ) and the wall thickness

Clachtoll entrance form in the community quarry at Spittal, Caithness in 2012-13. Weakening and removal of masonry from the inner wallface over an area of attenuated wall foot to simulate settlement failed to precipitate general collapse, and so the hypothesis was rejected. The masonry above the forced void simply arched, or bridged, over the hole but remained meta stable (see Chapter 8 The construction of broch towers)<sup>75</sup>.



**Figure 31** The sketch (top left) shows the attenuated footprint of the inner wall, shaded red. Any settlement into this footprint would lever the inner wall inwards from the stepped stones of the corbelled guardcell. This was simulated in a 1:1 model of the Clachtoll entrance and forced into failure. However, the stones above simply arched over the breach (curved purple lines). The breach was pushed through the guardcell wall (bottom left) with no further failure of the wall masonry

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to be  $t$ , and assume that the latter is reduced to half ( $t/2$ ) were an internal cell cuts into the inner wall footprint. The original area of the annular footprint,  $t(2r+t)$  is reduced to  $t(r+t/4)$ . Thus the ground loading, the mass divided by the footprint area would increase because the footprint area would reduce to c. 44% of the original, increasing the ground loading proportionately.

<sup>75</sup> The figure visible through the forced breach from within the guardcell is that of my late and much loved friend, Paul Humphreys who assisted with all my work in Caithness. *Ar dheis Dé go raibh a ann.*

## **Guardcells**

The small intramural cells entered from the sides of the broch's entrance passage are termed 'guardcells' although given their small size, their function in this regard might have been better exercised by dogs than by human beings. The cells are varied in the size and in the shape of their floor plans, vertical profiles and height.

Guardcells with additional openings into the garth are few, but include Clumlie, Shetland, Ousedale Burn, Caithness, Easter Kinnauld, and Clachtoll, Sutherland. At Dun Beag on Skye, a tholos occupies the position in which the RHS guardcell should occur, but is inaccessible from the entrance passage. This is interpreted as a relict feature, i.e. it was a guardcell in the initial passage construction but has been modified since. Most guardcells are slightly corbelled to narrow the gap to be spanned by lintels and the majority of guardcell roofs are lintelled. The ends of the lintels are built into the vertical walls of the cell (seen from beneath the cell cross-walls look like the reverse of a flight of stairs).

From 84 brochs examined, (Graham 1948; 56) 18 examples possess a guardcell on each side. Some 44 cases of a single cell have been recorded, of which 34 were on the right hand side (on entering the broch) and in 22 cases there are no guardcells.

The disposition of guardcells is highly variable and they were perhaps less favoured in the Northern Isles than in the West.

## **Ground level mural cells and galleries**

Brochs can have up to 5 entrances from the garth to mural cells<sup>76</sup>. One cell entrance, often in the 9 o'clock to 12 o'clock quadrant, accesses the staircase to the first floor and some brochs have staircases at first floor level also, accessing the second floor.

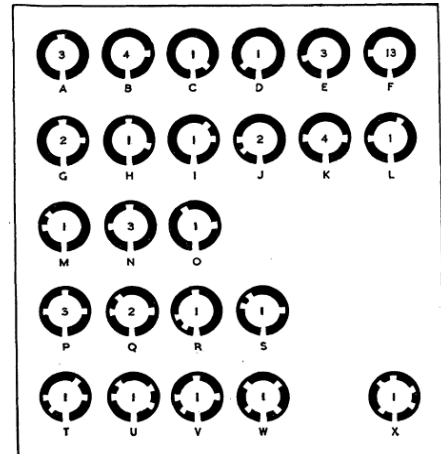
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<sup>76</sup> The term 'mural cell' is appropriate here because, given that the vast majority of brochs are solid based and that the ground floor cells are not restricted to the footprint of the downward projection of the gallery space, it would be misleading to call them intramural cells, i.e. they do not exist between the inner and outer walls of the broch, but within its solid base.

Only 6 of the 53 brochs for which evidence exists do not have a cell entrance in the left half of the broch in which the stairway is usually sited (Table 3.2). Amongst the 6 examples listed by Graham, Dun Carloway may be discounted because the relevant wallface had been largely reconstructed, and excavations by Tabraham have revealed a cell with its entrance at 9 o'clock. In addition, the RCAHMS Inventory indicates

TABLE III.—NUMBERS OF ENTRANCES TO MURAL CELLS.

Region.	Number of cell-entrances per broch.					Number of brochs considered.
	1.	2.	3.	4.	5.	
I. Shetland . . . . .	2	1	1	1	..	5
II. Orkney . . . . .	2	1	2	..	..	5
III. Northern Mainland . . . . .	15	10	..	1	1	27
IV. West Coast and Inner Islands . . . . .	4	3	3	..	..	10
V. Outer Islands . . . . .	..	1	..	1	..	2
VI. Central and Eastern Mainland . . . . .	2	..	1	1	..	4
Totals . . . . .	25	16	7	4	1	53



the possible existence of a further cell entrance at about the 9 o'clock position (see Figures 7.1 & 7.2b in Chapter 7: RCAHMS 1928, Tabraham 1977). In Dun Carloway, the stairway entrance lies at about the 1 o'clock position but observation of the masonry suggests that this is a secondary or rebuilt feature. Similarly, Mousa and Midhowe now have no stairway access at the ground floor level and neither does Caisteal Grugaig. These also are a challenge to the canonical RSM form and it will be clear that a broch with no ground floor garth entrances is not an RSM broch tower.

**Table 3.2 Ground floor configurations (per Graham Table 3 & Figure 2)**

Ground level cells are usually roofed by inseting lintels into their side walls, the latter being only slightly corbelled, if at all, in most cases. Their end walls, however, are commonly corbelled to roof height. However, examples of fully corbelled tholoi exist (Dun Beg on Skye or Dun Mor Vaul on Tiree, for example) and corbelling was not unknown to broch builders.

## Stairways

The SM2012 stairway is an unbroken helix set within the wall-void and running from ground to wallhead levels. No monument exhibits this feature; the helix at Mousa rises clockwise from Level 2 (*sensu* MacKie 2002, 11), some 2.1 m above the current solum, to the wallhead. No other broch has a helical stairway extending more than a single gallery high.

The RSM has separate stairways that rise clockwise from ground to first and then from first to second levels, as evidenced at 38 brochs (see Tables 7.3a to 7.3d; Chapter 7). The progressive convergence of the outer upon the inner wall rules out the extension of stairways into the higher galleries, as noted by McKenzie in respect of Dun Carloway;

-But I found it impossible to get to the higher parts; and, as the wall gradually grows narrower, I cannot comprehend how people could get to the top. (McKenzie 1792, 288)

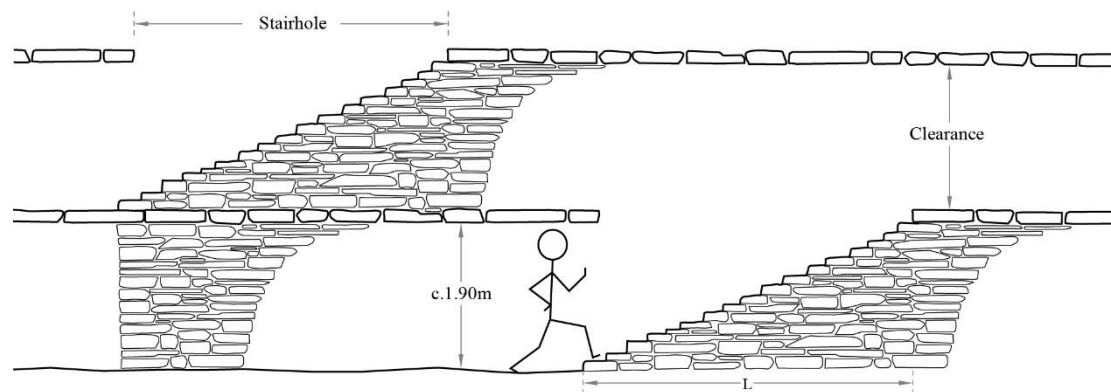
Measurement of the staircases suggest that they rise c.1.9 m over a ground length of about 3 m. The number of steps ranges from 14 to 19 with treads of 100 to 300 mm and risers of 100 - 150 mm. Given that the total rise is not much more than head height, the stairhole is almost as long as the stairway's footprint (Figure 32) and it extends the full width of the gallery or cell into which it has been built. In some cases, e.g. Kintradwell, a single corbelling reaches from ground level to the second gallery floor accessing the next gallery behind, i.e. anticlockwise of, the stair should be noted.

It is noticeable that the cell or gallery segment within which stairways are constructed is often narrower at the stair than elsewhere and this may reflect the need

**Figure 32 Putative configuration of the broch stairway**

to embed the stair slabs into the side walls. The stair treads are rarely longer than 1.1 m and many, perhaps all, have rounded edges, not attributable to use-wear, which suggests that they were collected and not quarried. The entrance to the stair usually gives access to a small cell, the stairfoot cell on the left hand side on entry, with the stair rising immediately right of the entrance. The external wall at the foot of the stair is the favoured locus for secondary entrances possibly because the door through the inner wall has already been made. Broch entrances that directly access the stairway are probably secondary entrances made through stairfoot cells.

It is anticipated for the RSM that broch towers should display stairways, at least from ground to first floor and first to second. With the exception of Mousa, no surviving broch or credible historic record exists with a higher stairway.



### Basal Galleries

Basal galleries are not consistently recorded in the archaeological record and in some cases, lengthy cells are treated as galleries, but not in others. In ruinous monuments, the ambiguities are increased because galleries, seen intermittently are identified as cells as at Alltbreac, and *vice versa*. Given that one of the sub-categories of



traditional, i.e. MacKie, broch typologies, is the Ground Galleried Group, one must wonder even more at the lack of clarity in their definition<sup>77</sup>.

Graham (1947, 61) records only 5 unambiguously known basal galleries with 8 probable examples. In the less reliably defined/identified class of 'partial galleries' a further 12 monuments were included. Accepting all of these as ground galleries the reputed frequency of their occurrence is something of a myth. They are said to be a feature of western brochs and Gurness and Mid Howe in Orkney are exceptions, not least because they, and the now lost site of Redland, have all clearly collapsed, in whole or part, early in their histories, requiring additional works and modifications.

Ground galleries and basal cells are diagnostic features of brochs (*sensu lato*) and stairways are strong indicators of broch towers; their absence confirming that the remains in question are not those of a tower<sup>78</sup>.

### **Upper Galleries**

First level galleries were recorded at 23 brochs, and in one broch at second floor level, three brochs at third floor level, none at fourth and one each at fifth and sixth, making a total of 29 galleries or gallery fragments, known to Graham (1947, 62). It is frequently observed that the galleries above the second floor at the Glenelg brochs are not brought to a fair face, and this is the case in all the galleries at Mousa and in one at Clickhimin. Graham accepts that this implies they were not used as passages, albeit that this does not rule out their use for storage, with infrequent access. It also, of course, assumes no soft furnishings within the broch wall, an assumption that may

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<sup>77</sup> Commenting on Dun Fiadhairt broch, MacKie acknowledges that it should be a transitional type per his own classification (MacKie 2002, 2) half way between a ground galleried and solid based broch, but since this would distinguish it from the other Skye brochs, he declares it a ground galleried broch (MacKie 2007b, 813). The problem needs to be resolved by firstly defining what a gallery may be and setting some criteria for their recording.

<sup>78</sup> It will become clear later that modifications to inter and intra-mural voids (Thrumster and Midhowe) and the insertion of new voids (Dunbeath) somewhat complicate the picture. The position in 2012 is that set out here, but it is one that fieldwork has now shown needs review. This is another case in which the paradigmatic belief had so overshadowed the field observations that the possibly diachronic nature of mural features was simply not considered.

not be well founded. At Dun Carloway, the third level gallery is roughly 300 mm wide and the upper galleries at Dun Troddan and Dun Telve converge below the wall head.

It is proposed here, and consistent with the position set out above for the nature and purpose of the double wall, that the upper galleries in all brochs narrowed to inutile dimensions, finally being formed into a single wallhead. The latter would form a toroidal mass at the wallhead and contribute to the broch's stability and this is the configuration used in the RSM<sup>79</sup>.

### **Scarcements**

Projecting stone ledges, in-setting of the upper inner wallface or construction of an inner lining wall are devices used in some brochs to form *scarcement ledges* (Graham 1948; 8 *et seq*). The scarcement is set at the height of the innermost entrance lintel, which usually projects beyond the wallface to form part of the scarcement.

In the SM2012, these are interpreted, variously, as supports for wooden flooring or for a roof (Scott 1947; 9-10) but unambiguous evidence for either proposition is generally wanting. Some support for the existence of internal structures in wood is provided by broch excavations that have revealed traces of the post-holes of structural posts within the garth. The earliest excavated example, at Dun Troddan (Curle 1921), comprised 11 postholes in a curvilinear setting. At other sites the evidence comprises a scatter of post holes in no particular arrangement, save for those at Scalloway, which form a clear arc concentric with the inner wallface, but less than 1 m from it (Sharples 1998, 26-7). Sharples argues that these postholes formed part of a system of radial segmentation of an annulus around the inner wallface (*ibid*). He also, however, dismisses the existence of post hole rings at Dun Mor Vaul and Crosskirk. At Dun an Ruigh Ruaidh (MacKie 1982) 19 post holes

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<sup>79</sup> I am grateful to Dr Theodossopoulos for his observation that if this wallhead mass were subsequently pushed out, by a collapse of the roof for example, it would cause extensive damage both at the wallhead and below it.

were found in the undisturbed clay underlying the monument. The nine largest post holes form an ellipse. The excavator interprets their use as the main post ring of a conical roof that rested onto the scarcement within the broch (MacKie 2007b, 770 and his Figures 7.364 and 7.371).

Converting this scatter of post holes from a handful of sites into standard and highly regularised internal structure of multi-floor mezzanines with conical roof has been one of the great achievements of Scottish Iron Age studies, but one perhaps more honoured in the breach than the observance.

Harding, noting these post hole settings and the modest lean-to structures postulated for their use, suggests that the treeless nature of the Highland and Island regions was understood by earlier writers to limit the structural possibilities for internal furnishings in broch towers (Harding 2009a; 101). This writer, whilst undertaking conservation work in the area of the broch's entrance, discovered at

Clachtoll broch a deposit of burnt hazel round-wood of modest scantling on the upper surface of the scarcement (Appendix Clachtoll). This was radiocarbon dated<sup>80</sup>

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<sup>80</sup> Laboratory reference numbers SUERC-36728; GU25244

to the calibrated interval 111 BC x 55 AD<sup>81</sup> (93.9% probability) or 53 BC x 22 AD



**Figure 33** In this illustration dating to c. AD 1300 the long ladder/ramps have been stiffened behind by stronger poles, but otherwise the ramp-ladder and the hanging scaffoldings are clearly of wattle work. Note also, the little figure at the wallhead levelling with a plumb-level. Save only for the use of mortar – evidenced by the trowel – there is nothing in this illustration that could not be encountered in the Scottish Iron Age. (after the British Museum’s Egerton manuscript, as reproduced in Binding 2004, 87, his Figure 268: creative commons ©).

(at 68.2% probability). Its import here is that it indicates the probable use of wattle screens as flooring for the putative floor resting on the scarcement, a suggestion avoiding the need to imagine the procurement of many timbers in a treeless landscape, and one consonant with Harding’s observation (ibid) that the area ÷ doubtless supported only relatively light birch or hazel woodland.ø quite so. One robust, or two or three lighter layers of wattle screens would construct a floor easily capable of carrying normal household weights, including people. Such screens, apparently used singly, furnished the access ramps and floors for scaffolding in major medieval building projects (Figure 33).

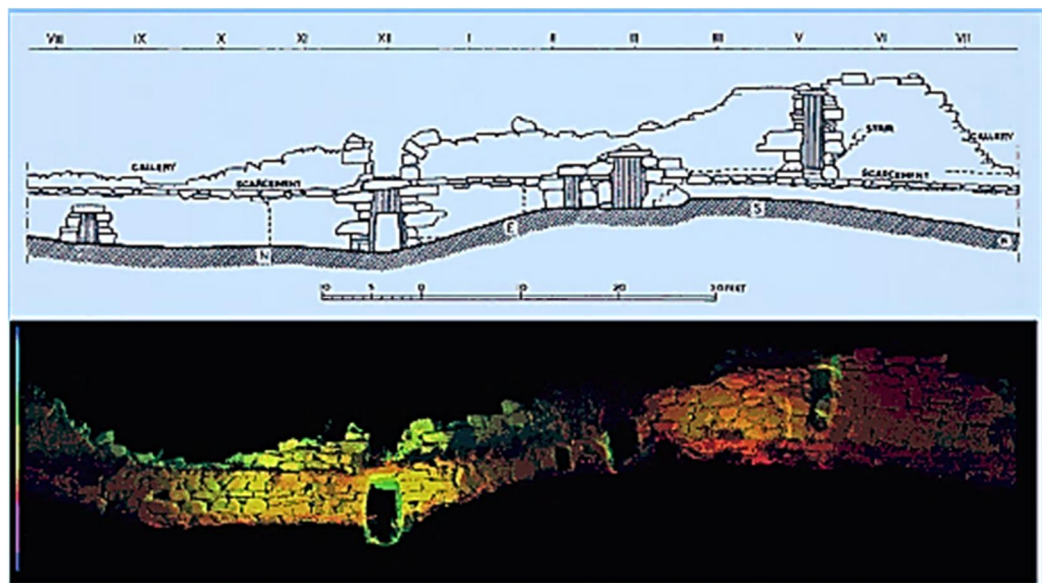
Harding’s additional suggestion (ibid) that a timber framework would have been required to support the corbelled ends of cells and galleries is simply mistaken, as

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<sup>81</sup> The ÷ø in this notation means ÷some single year between the cited datesø

demonstrated by the writer's work in building corbelled curves in Spittal. His concerns about the timber supply for broch building can be tempered by the knowledge of the suspended or hanging scaffolding (Figure 33) which would greatly reduce the demand for substantial timbers.

The scarcement at Caisteal Grugaig, a broch apparently built against a relatively steep slope, is some 2.1 m above the solum at the entrance but only 0.7 m above it opposite the entrance (Figure 34) and is not level throughout its circuit. It is unlikely that this served as a roof footing, but it could have supported a floor, up through which access was provided from the entrance, which sat beneath floor level (Appendix 6.1). However, a combination of debris within the broch ó not bedrock ó and some downhill settlement left of the entrance explain the unconformity of this feature.



**Figure 34** CAD illustration derived from a laser scan image of the inner wall of Caisteal Grugaig, colour coded for its distance from a right cylinder centred in the broch (lilac nearest, green furthest). The scarcement can be seen above the entrance (left of centre) with its level rising in both directions over a span of >500mm.

At Black Spout, Pitlochry, a partial scarcement was discovered on the uphill side of a thick-walled, Iron Age roundhouse, where it sat 1.1 to 1.45 m above the irregular, quarried, bedrock surface (Strachan 2013; 23). Hypothesising a continuous and

horizontal scarcement Strachan presents the obvious alternatives of the scarcement as floor support or as roof support and speculates further on the possibility of a smaller roofed structure freestanding within the excavated round wall and the possibility of more elaborate roofing than the ubiquitous 45-degree conical model. Tacitly acknowledging the absence of evidence sufficient to select any of the proposed reconstructions to the exclusion of the others, Strachan argues that:

-In one sense the actual configuration of the building at the Black Spout enclosure is of secondary importance: big roof or small, the aim was the same, to present (Strachan 2013; 104).

In conclusion, he clearly assumes that the aggrandised monumentality of the structure is an Iron Age, not a 20<sup>th</sup> century conception and he argues that the presence of a large roof would dominate the aesthetics of the buildings appearance, reducing its monumentality, whilst a smaller house contained within the drystone built envelope would allow fuller expression of the latter's drystone built monumentality, a quality he takes to be self-evident.

High scarcements have been noted at Dun Telve and Midhowe and while the former is certainly a primary characteristic of the original build the latter is less convincing. Similarly, mid-level scarcements are also noted, e.g. at Mousa, and these are discussed in Chapter 9. Broch towers, in the RSM, should exhibit scarcements, but where these relied on inner lining walls, the loss of the lining wall may create the illusion of their absence. Extant evidence for a wooden substructure is weak and ambiguous.

### **The inner wall**

The inner wall in both SM2012 and RSM is vertical and of uniform thickness as it rises. Its form is that of a right cylinder, consistent with MacKie's criterion that the inner wallface of a broch tower is circular. It comprises two wallfaces through-bonded at intervals, the inner wallface encircling the garth and the outer wallface being also the inner wallface of the gallery voids. As noted, it is punctuated with stacked voids and cell and gallery entrances, including voids accessing the putative floor atop the scarcement.

The outer wallface's vertical profile in the SM2012 broch is curvilinear. Amongst extant brochs, this profile is evidenced only at Mousa and is variable around the circuit of the outer wallface (See Figure 65). Mousa's outer wallface rises more or less linearly at first and then curves inwards as it rises; the outer wall thickness reducing with height. The curve of the SM2012 model's outer wallface reverses at a given height, usually at or just above the second gallery. At about the same height, the reverse curve of the outer wall's inner wallface begins to corbel inwards so that the outer wall head, projected onto floor level, lies over the intramural void.

The inner wall in both SM2012 and RSM is vertical and of uniform thickness as it rises. Its form is that of a right cylinder, consistent with MacKie's criterion that the inner wallface of a broch tower is circular. It comprises two wallfaces through-bonded at intervals, the inner wallface encircling the garth and the outer wallface being also the inner wallface of the gallery voids. As noted, it is punctuated with stacked voids and cell and gallery entrances, including voids accessing the putative floor atop the scarcement.

The SM2012 should be revised to reject the curved profile of the outer wall and replaces it with a smooth inclined plane, as evidenced on many brochs but most clearly on the Glenelg brochs. Whilst linear, the angle of slope may vary, sometimes significantly, around the broch's circuit. It is improbable that this variation was a design feature or the consequence of poor construction but the quality of broch stonework in general militates strongly against the latter. It is more probable that the variation is a consequence of settlement and/or repair or rebuild following a partial collapse of the structure. Thus, the final form proposed for the revised standard model (RSM) broch is that of a frustum of a cone.

## **Diagnostics**

Based on the features discussed above, a list of thirty diagnostic features was prepared and the relevant observations were made on site and garnished from the extant literature. The observable diagnostics are listed in Table 3.3 in order of their

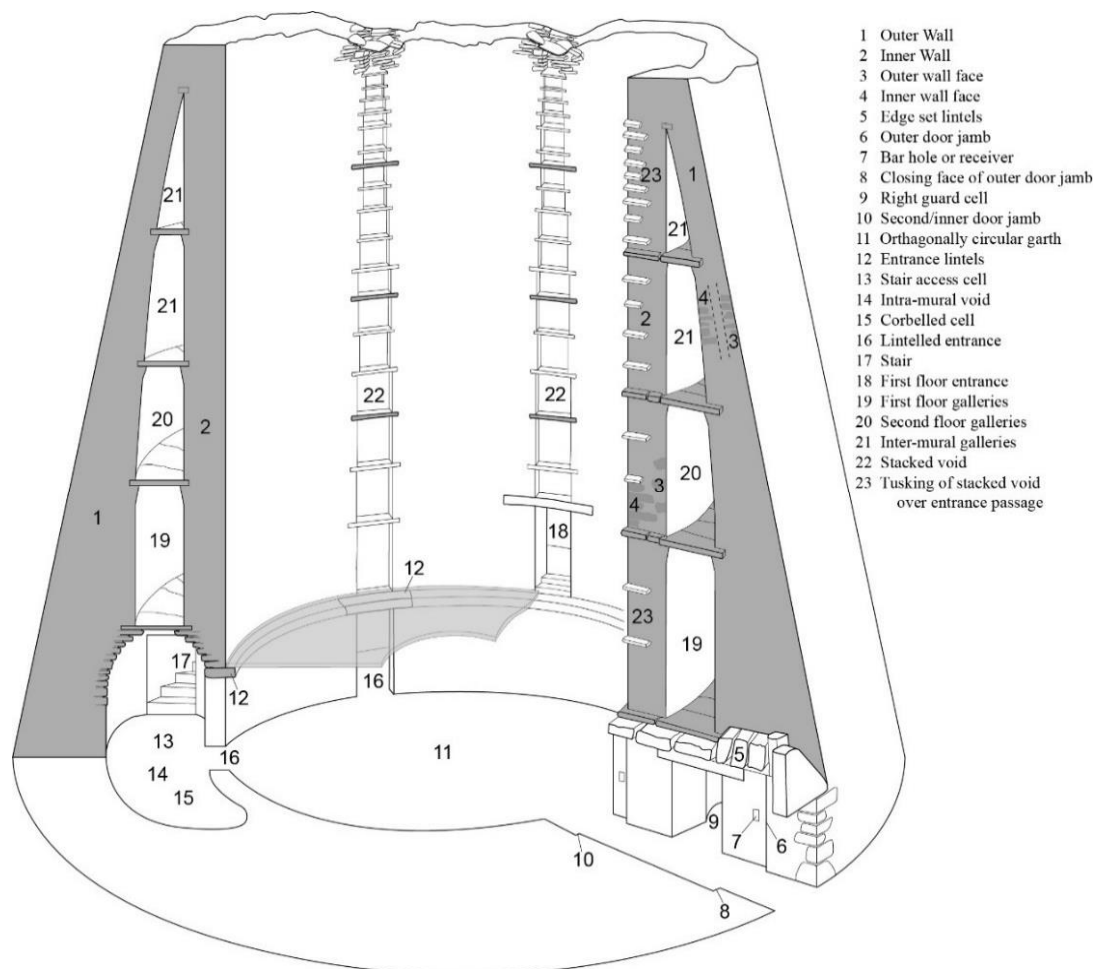


**Figure 35 Dun Telve, Glenelg is illustrated here to show that the outer and inner walls converge with height and meet just below the wallhead. The high scarcement is visible in the right hand image and it is generally speculated that this lies at the wall convergence level and perhaps 1 m or so below the final wallhead. The weeping lime salts probably result from relatively recent conservation, some of the stones of which can be seen just right of the excrecence, supporting the view that the stones filling the intramural space above that level are as originally built**

incidence, i.e. their frequency of occurrence. The fine grain of this exercise is discussed further in Chapter 7, but it is useful to set out the observable diagnostics from the 73 brochs on which they were seen in the field, from the literature or from historic records. Of the 2190 observations that it was potentially possible to make on the set of 73 brochs in the study sample, only 711 could actually be made, i.e. 32%. This ought to inspire a measure of conservatism in the conclusions founded on the possible observations. There is rarely serious disagreement between scholars over the individual observations (but see Smith Forthcoming, re Clickhimin and MacKie's interpretation of that monument). The major differences proposed here relate to the paradigm from within which the observations are made and the way in which this preconfigures their interpretation. Comfort may also be taken from the fact that the vast bulk of the observations are consistent with the descriptions set out here and of the 711 observations made, some 34 instances were observed in which the context in



which the observation could be made was present but the anticipated diagnostic was not observed; a 5% error rate (Table 3.4 for summary of Table 7.3e) In practice, many of these contraindications are readily explained by secondary building within the broch or obscuring debris.



**Figure 36** The form and configuration of the Revised Standard Model broch, the RSM. Only its structural elements have been included in this illustration and the stairfoot cell on the left is included for illustration only, the stair proper would be entered at 16. The relationships between observations and interpretations of these and other features of the SM2012 and RSM configurations are tabulated in Table 3.5.

<b>Incidence of observable diagnostics in 73 brochs</b>	
Diagnostic	Incidence
Galleries at first level	66
Internal radius	51
Wall thickness ≤ Internal Radius	45
Typical entrance furniture	41
Scarcement at entrance lintel level	39
Precision of r	38
Stairways... 1/2	38
Galleries at ground level (1 to 5)	35
Corbelled chamber over the outer passage	31
Corbelled cells at ground level	30
Outer wall battered	30
Inner wall orthogonally circular	27
Lintelled cells at ground level	26
Stacked void over the inner passage	24
Galleries above first level	21
Relict stacked Voids	19
Stacked void over stairway entrance	19
Differentiation of entrance lintels	18
Inner wall vertical or near vertical	18
Pinnings between building stones	17
Inner lining wall	14
Extant Tower	12
Outer wall circular in plan	12
Stairways... 2/3	12
Scarcement at mid-level	10
Stairways higher	7
Batter angle	4
Scarcement at high level	4
Levelling slabs	2
Historical records only	1

**Table 3.3 Diagnostic features recorded from 73 brochs (see Tables 7.1 and 7.3a Table to 7.3d for further details)**

Diagnostic	Incidence	Contraindicated
Scarcement at entrance lintel level	39	10
Wall thickness ≤ Internal Radius	45	6
Outer wall circular in plan	12	6
Inner wall orthogonally circular	27	4
Stairways... 1/2	38	2
Typical entrance furniture	41	1
Corbelled chamber over the outer passage	31	1
Inner wall vertical or near vertical	18	1
Stairways... 2/3	12	1
Stairways higher	7	1
Scarcement at high level	4	1

**Table 3.4 Incidence of contraindication of diagnostics.**

**Table 3.5 A comparison of features under SM2012 and RSM noting differences in their observation and interpretation.**

<b>Fig 36 key</b>	<b>Feature</b>	<b>SM2012</b>	<b>RSM</b>
1	<b>Outer wall</b>	Sinusoidal curve in vertical section	Linear in vertical section
3	Outer wallface	Excellent masonry with pinnings, large stones closer to ground	As SM2012. Largest stones concentrate in entrance area
4	Inner Wallface	Smooth in two lowest galleries, rough elsewhere	AS SM2012
	Metrics	Existing measurements wildly inaccurate and quite unreliable	Laser scans shows walls circular in horizontal plane with some distortion due to collapse episodes.
2	<b>Inner Wall</b>	Right cylinder	Right cylinder
(3)	Outer wallface	Smooth in two lowest galleries, rough elsewhere	AS SM2012
(4)	Inner wallface	Excellent masonry with pinnings, fewer large stones closer to ground	As SM2012. Largest stones concentrate in entrance area
	<b>Entrance engineering</b>		
5	Edge set Lintels	Infrequently observed Structural significance not noted	Outer lintels of passage roof are edge set and lowest of the lintels, central group are massive but set flat and inner group are thin and non-loadbearing. Part of the entrance engineering solution
23	Stacked void over entrance	Observed by MacKie Structural significance not noted	Part of the entrance engineering solution
	Cell over the entrance	Observed by MacKie Structural significance not noted	Part of the entrance engineering solution
	Massively built walls	Generally observed Structural significance not noted	

Fig 36 key	Feature	SM2012	RSM
6	Outer Doorjamb	Entrance furniture	Entrance furniture
7	Bar hole receiver	Entrance furniture	Entrance furniture
8	Closing face of outer doorjamb	Entrance furniture	Entrance furniture
9	<b>Guard cells</b>	Commonly observed Structural significance and frequency of modifications not noted	Bottom of lintel lies in plane with barhole and base of outermost lintel. RHS guardcell frequently rebuilt so barholes and other features lost, realigned or terminating in the cell.
10	Second, inner, doorjamb	Observed	Secondary and possibly very recent structures, in general
11	Orthogonally circular garth	Observed, mainly by MacKie, sometimes recorded as elliptical	Observed as sine qua non. Misreported as elliptical when measured non-orthogonally
	Scarcement/s		
	Low level scarcement	inner edges of the entrance and stair lintels form part of the scarcement whose height they determine. Variations observed their significance for rebuilding not noted.	Low scarcements have been modified extensively and are sometimes thickened, sometimes omitted in rebuilds.
	Mid level scarcement	Observed and noted as original features	Secondary features where they occur. Usually associated with blocked entrance passage, lintels of which have been slapped out, and secondary entrances, often above the original.
	High scarcement	Observed and noted as original features	One certain and one possible original high scarcements exist, all others are secondary modifications.

Fig 36 key	Feature	SM2012	RSM
12	Entrance Lintels (main and stair entrances)	Lie in the plane of the scarcement	Exceptions are secondary adaptations
	<b>Stairways</b>		
13	Stair foot cell	Observed	Observed
15	Corbelled cells	Anticlockwise walls of stairfoot cell and some guardcells corbelled	AS SM2013. The significance of the projection of the stairfoot anticlockwise wall corbelling misunderstood and remnant fragments unidentified.
17	Stair	Believed to form helix (not spiral) to wallhead	Stairhead access only at Mousa and probably Viking intervention. Otherwise single flights between ground and first floors and between first and second floors only.
18	First floor entrance	Observed	AS SM2012
	Wallhead	Assumed accessible and with wallwalk	Assumption not supported by evidence, Mousa is not viable example, supposed wallwalks on Orcadian examples demonstrably secondary and built over collapse debris.
	<b>Galleries and Wallcells</b>		
19	First floor galleries	Accessible and walls have fair faces	AS SM2012
20	Second floor galleries	Accessible and walls have fair faces	AS SM2012. But note that common assumption that upper voids are similar is not supported by the evidence.
21	Intra mural high voids	Assumed that upper voids remain wide and provide access to wallhead	SM2012 assumption unfounded. Above the second floor level the sidewalls converge and are not brought to fair faces

Fig 36 key	Feature	SM2012	RSM
14	Intra-mural voids	Cells within basal wall thickness, observed	AS SM2012
16	Lintelled entrance	Observed	Observed
22	Stacked void	Various interpretations, for light ingress, for smoke egress, drying void, etc	Uniformly for relief of compression forces at structurally weak positions.
	Relict stacked voids	Variouly interpreted as aumbreys, cupboards, wall void access, etc.	Shown to have been fragments of stacked voids made relict by redesign and rebuild, always secondary, often late in settlement sequence.

## The form of the RSM

The illustration of the RSM (Figure 36) represents the writer's revision of the evidence available in 2012 and Table 3.5 compares the observation and interpretation of features in SM2012 with those in the RSM. Figure 36 has been annotated with the terminology used throughout this thesis to describe the various parts of the monument type. It is, arguably, a crystallisation of key elements of an emergent view on what a broch can be conceived to have been. If brochs were canonical structures, the illustrated elements of the RSM should be detectable in the surviving broch remains, to greater or lesser degree, and other forms or divergent forms should not exist. In addition, its form and proportions should be recognisable in the remains.

Alterations to the built RSM could mask or obscure its original form and proportions. MacKie, referring to the 'increasing number of discoveries that brochs were often deliberately and substantially demolished in Iron Age times' (MacKie 1965, 104), lists Jarlshof, Dun Mor Vaul, Midhowe and Keiss South (aka Keiss Harbour) as examples. Whilst, intuitively acceptable, his is not a substantive case, and the use of 'often' in the cited passage may not be justified by a list of four examples. Field examination of Keiss Harbour, Jarlshof and Midhowe (reported in Chapters 6 & 7) found no support for the assertion that brochs were dismantled in the Iron Age. Harding's review of secondary occupation of Atlantic Roundhouses (Harding 2009b)

considers features within the brochs of Dun Mor Vul, Clickhimin, Yarrows, Midhowe and Gurness and considered the difficulties these create for identification and interpretation, but touches only lightly on issues of architectural engineering. MacKie, and to a lesser extent Harding, interpret the brochs as if they were simply the ruins of original structures dilapidated by natural forces and reused for human settlement but suggest that the surviving and modified monument remained essentially as they were originally built.

The interplay of natural and anthropic forces in the formation, re-formation and destruction of monuments and sites is generally accepted in archaeological studies (see Schiffer 1996 for examples) and broch towers are unexceptional in this matter. While complex building histories create heterogeneous remains, the challenge faced in this study is that of trying to explore the possible homogeneity of the original built form, or accepting that this also was heterogeneous.



**Figure 37** The central panel on the reverse side of Sueno's Stone, a possibly 10<sup>th</sup> century decorated Pictish monolith, is thought to display the aftermath of a battle with decapitated bodies on the left and apparently armed persons on either side of a truncated cone shape which may have been intended to represent a broch tower. Similarly, the gaming piece from Scalloway may be a three-dimensional representation of a broch tower.

Two putative and near contemporaneous representations of brochs survive to us, the first a sculpted shape on the back of the Sueno's Stone cross slab (Henderson and Henderson 2004, 135) and the second, a gaming piece excavated at Scalloway, in Shetland (Sharples 1998, 173, 175). Both representations are reproduced here as Figure 37). These images are not unambiguous evidence of the forms of original brochs but such evidential value as they possess point to the truncated cone shape deduced from the surviving remains. It should be noted that Sueno's stone is thought, on art historical grounds, to date to c. 900 AD and is more than a millennium later than the initial broch building episode. However, the esteem in which Picts seem to have held brochs is demonstrated by their common reuse of brochs and broch sites and it is not impossible that a notion of a heroic age of brochs may have informed the sculptor of Sueno's stone, albeit that few brochs, more than currently but probably fewer than 20, would have survived to full height at that date. Thus, the uncertainty of the identification is necessarily acknowledged, as is the absence of an alternative credible interpretation.

### **Circularity**

As noted, Graham and MacKie have commented on the issues involved in measuring broch diameters (Graham 1948, MacKie 1965) as has Fojut (1983) and this matter is further discussed in Chapter 7. Nonetheless, there is consensus on the issue of the circularity of the broch, in horizontal section and this is one of MacKie's defining factors (Chapter 2). The proposed structure of the RSM suggests that the internal diameters of brochs are constant with height, whilst the external diameter reduces with height. In decay, the effect of the obliquity of the erosion plane with the vertical axis is such that the inner and outer wallfaces will appear as ellipses in the erosion plane (Figure 38) the latter with greater eccentricity than the former.

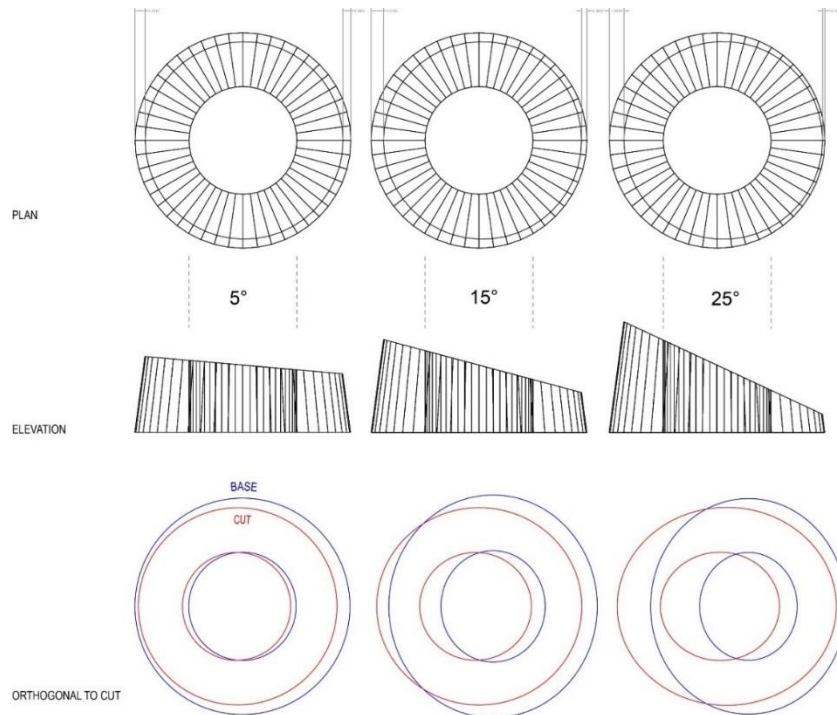
At Alltbreac<sup>82</sup>, Mackie measured two external diameters and wall thicknesses, from which internal diameters of 9.9 and 7.2 m can be calculated, a variation of 2.75 m in

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<sup>82</sup> Also Alltbreck and, more correctly, Allt Breac



diameter (MacKie 2007a, 625). Mercer's survey suggests that the external diameters are 20 m by 35 m, giving even larger variances (Mercer 1980; 125). Laser scan survey has shown that the internal wallface is very near a true circle (see Appendix Alltbreac and Appendix *Broch survey and analysis*) indicating that the variance from orthogonal circularity may be as small as  $\pm 10$  mm. Similarly, MacKie has measured several monuments, using theodolite and steel tape, and recorded their circularity to precisions ranging from  $\pm 20$  mm, at Dun Telve to  $\pm 120$  mm at Caisteal na Coille and

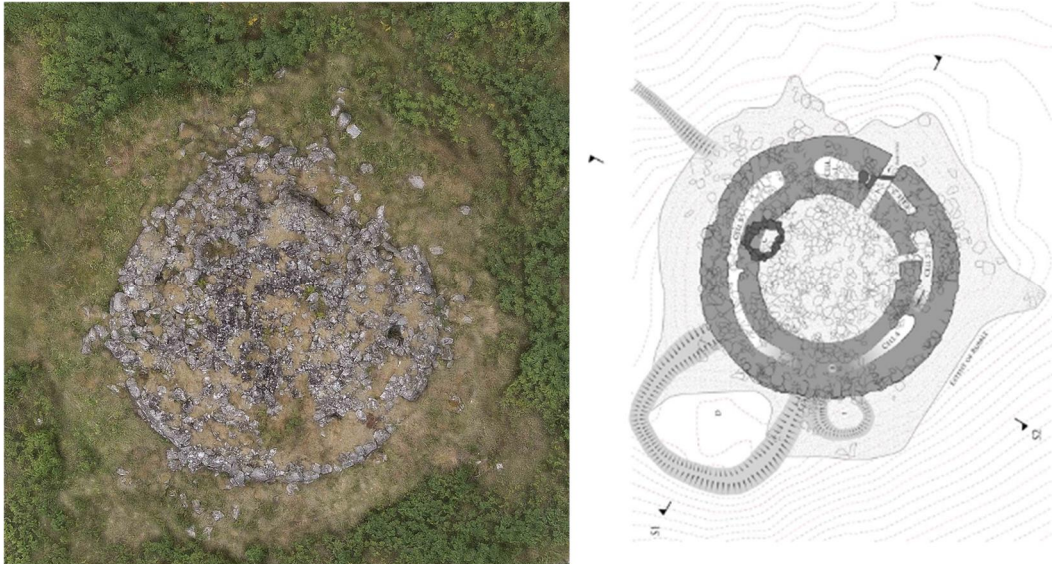


**Figure 38** A cylinder within and concentric with a cone cut by a plane inclined at 5, 15 and 20 degrees and the top of the structure is recoded orthogonally to the inclined plane, i.e. not to the notional horizontal plane. The view orthogonal to the inclined plane, labelled ‘orthogonal cut’ and shown in blue, shows twin ellipses for the cylinder and cone, the latter rapidly becoming more eccentric than the former. [note that the base circles also become elliptical when viewed orthogonally to the inclined plane.] © AOC Archaeology Group, generated by G Cavers.

East Burray.

The brochs of Clachtoll and Caisteal Grugaig are both built on markedly irregular and steeply sloping ground. The height difference between the highest and lowest points in their basal courses are over 1 m at Caisteal Grugaig and just over 3 m at Clachtoll. However, laser scan survey again demonstrated that at and above the level

at which the full circuit of the masonry emerged, these inner wallfaces are also truly circular to close tolerances (Figure 39 and Figure 40). This demonstrates the ability of broch builders to construct to orthogonal circles, despite adverse on-site topography. It would also have required close control of horizontality, as well as circularity throughout the build.



**Figure 39** The inner wallface of Alltbreac is shown by laser scan survey to have been constructed as a right cylinder, circular in orthogonal section. (see Appendix Alltbreac for further details). Left image © Forestry Commission, right image © AOC archaeology Group

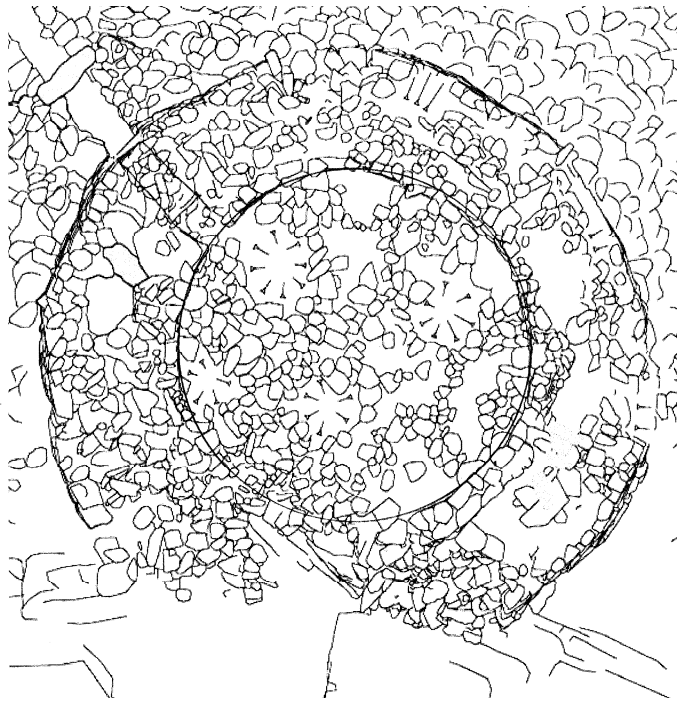
The RSM proposes that all broch towers should be considered to have been truly circular in orthogonal plan view and that this is an essential characteristic of broch towers.

### First fixings

Apart from scarcements, there is no direct evidence for the first fixings<sup>83</sup> of brochs. The postholes found in a handful of brochs have been speculatively enlarged to

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<sup>83</sup> In modern construction, First Fixings (also first fix) are the works necessary to bring a completed structure from foundations to plastering of internal walls, and includes the insertion of floors, ceilings and utilities.



**Figure 40** This outline plan was derived from the laser scan surveys of Clachtoll broch. Onto its inner wallface a circle of best fit has been drafted which indicates a very close approximation to true circularity everywhere except in the upper right quadrant, where the wall head had been both displaced and rebuilt in the recent past.

complex wooden structures of several storeys of mezzanine floors presumably under an oculus that allowed smoke to vent from the building.

The emphasis of this study is placed squarely on the structural remains of brochs and consideration is not given to putative wooden structures within brochs or to

secondary features found mainly in Eastern and Northern brochs and which are commonly conserved, anachronistically, within the excavated garths. Brochs contain no built-in provision for fires or smoke venting and the absence of such has driven the supposition that mezzanine floors would necessarily have been built to allow smoke to vent. On the other hand, hearth sites occur in profusion at all levels within the deposits infilling brochs (see, for example, Curle 1921, for this phenomenon in Dun Troddan). These are usually square or rectangular areas demarcated by a stone kerb, usually of upright stones, revetting deposits of ash and fire debris. They characterise broch deposits at all levels, from primary to abandonment. Accepting that no structural accommodation exists for smoke venting, the hanging lum, common in later vernacular structures, could have met the need without constraint to the structure's second fixings and without requiring the inspiration of an elaborate

timber built internal fitting which strains both the available timber supply and credibility<sup>84</sup>. See comments on work of John Hope, pp 361-3.

## Second fixings

Little is known about the second fixings of brochs, i. e. the works undertaken after the structure with its walls, floors ceiling and roof are in place. Finds of socketed stones, sometimes called spud stones, are relatively common. The shallow socket housed the foot of the closing stile of the door, acting as a hinge. These are sometimes found *in situ* beside a doorjamb. It is assumed that the doors were wooden, although large stone slabs could have served the same function<sup>85</sup> and been fireproof. As noted, the features surviving within brochs are generally accepted as secondary insertions and they will not be considered further in this study. The one exception is that of the wells or cisterns found in many, indeed in most brochs that have been excavated to the primary floor or close to that level. These range from modest holes to elaborate stairways accessing cistern-like subterranean chambers e.g. those at Midhowe and Gurness (Chapter 6).

Writing in 1947, Angus Graham noted the existence of 26 monuments at which some provision had been made for the extraction or storage of water; 13 in the northern mainland, eleven in Orkney and two in Shetland. Acknowledging the biases in this distribution, which he suggests reflects distribution of modern effort and exploration rather than distribution of occurrence, he suggests that save for a few instances, ÷ there is no reason to suspect that they do not belong to the primary period of habitation.ø(Graham 1948; 76). The wells or cisterns, are rock-cut, albeit that some additional masonry linings have been inserted. Eighteen wells have steps leading down to the water. This group occurs in 16 monuments, viz, Burray (E.), Burrian (N.

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<sup>84</sup> A hanging lum is a canopy above an open fire that is suspended from the roof or fixed to an external wall to allow smoke, fumes and sparks to exit through a hole in the roof or by percolation through the thatch. The space within its canopy was often used, in the 17th and 18th century blackhouses to smoke fish and meat. It was often made from clay-plastered woven withies.

<sup>85</sup> At the Cathedral of Santa Maria Assunta, on the island of Torcello in the Venetian lagoon, very large slabs of Istrian Stone are used as window shutters, Uncut projecting tabs, at the top and bottom of one side of the slab fit into holes in corbels projecting from the masonry.

Ronaldsay), Gurness, Hillhead, Hill of Works, Jarlshof, Keiss, Keiss Road, Kettleburn, Kintradwell, Loch of Ayre, Mamie Howe, Ness, Netlater, Oxtro and Redland. The remaining 9 wells or cisterns have no steps and lie in eight brochs, viz, Burroughston, Carn Liath, Dunbeath, Elsay, Mousa, Nybster, Ousedale Burn and Skirza Head. The well at Burgh Head, sometimes referred to as a Roman Bath is of comparable dimensions to that at Skirza Head, but set within a larger chamber (ibid). The well at Mine Howe has the structural and morphological characteristics of other broch wells but its excavators seem insistent on a non-broch structural formula for its interpretation.

Slab-built tanks are rather more common, indeed virtually ubiquitous to brochs but Graham's suggestion that every broch containing tanks also contained a well or well-like feature merits re-examination. Speculations about the tanks include the storage of water or the storage in water of shellfish and perhaps crustaceans.

## **Drains**

Drain like features have been noted at several excavated brochs including Thrumster, Midhowe, Dun Rihroy, Scirza Head, and others. In general, these have not been well studied which may be because of their inaccessibility beneath later structures, especially on the eastern and northern brochs. At Midhowe, a slab covered, drain-like structure abuts the inner wallface. Whilst this may be a drain, its location suggests an alternative use, that of a levelling device for the broch construction. Filled with water, it would furnish a control level which could be gauged by plumbob from the wallhead as it progressed. Such levelling devices are known from older structure, including the Egyptian pyramids.

Although paradigmatically assumed to have been domestic residences no effort has been made to explore the provision of water and the removal of waste products at broch towers, both of which would have required drains, where water cisterns were not dug or would not have provided water if they were dug. Wells immediately abutting the coast, like those at Midhowe and Gurness do not now contain water in any quantity and it is improbable that they ever did and the same must be true of

wells dug atop rocky pinnacles, like the Skye brochs. Cut into sand, the wells at Carn Liath and Kintradwell are similarly unlikely to ever have held water.

## Roofs in the Iron Age

Romankiewicz has, in publication, generally opted for 45° conical roofs atop the standard Mousa-shaped tower (Romankiewicz 2011)<sup>86</sup>. The case for building conical roofs is most strongly asserted by Dennis Harding, who attributes a 45° slope-angle to the circular structures of the period (Harding 2009a). It is worth deconstructing some of Harding's assertions in this matter, not least because they have been so influential. Having noted a long-accepted tradition that a roof pitch of 45° or more is necessary to cast off rain and avoid water-logging, he suggests that:

A pitch of around 45 degrees will also minimise the lateral thrust of the roof on the upright timbers, and at the same time presents the minimum area of roofing to be thatched (Reynolds, 1979, 33) (Harding 2004; 59)

What Reynolds actually published was the suggestion, without supporting evidence, that 'For a thatched cottage the minimum functional pitch is 45°, and he further asserts that a pitch of 45° is mathematically most attractive, because at this angle

there is less lateral thrust on a point of moment, major thrust being exerted at 22.5° and 67.5°. (Reynolds 1979; 33).

These suggestions, are interesting but untrue. Using FRAMEWORK software (2.ver 10.49) the lateral thrust (H) and the deflection in the rafter member ( - measured in m) were assayed (by Dr D Theodossopoulos) for roofs with inclinations of 60, 45, 30 and 15 degrees. The rafters were nominally 200 x 200 mm and the diameter of the circular structure was set at 5 m. The results are set out in Table 3.6.

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<sup>86</sup> This is very clear from Vol II of her BAR report. However, she has explored the possibility of other roof types in Vol I, see for example her illus 200.

It will be clear that that the lateral thrust, which would be at zero for 90 degrees, grows as the slope is decreased and does not minimise at 45 degrees. The behaviour of the beam in deflection is more complex but again has no special relationship with

**Table 3.5 Lateral thrust (H) and beam deflection ( $\delta$  m) in a circular structure with nominal parameters for size, beam cross section and load.**

Slope in degrees	H	$\delta$ m
60	3.61*e3	0.098
45	4.41*e3	0.078
30	6.23*e3	0.11
15	11.81*e3	0.336

a 45-degree slope. The magical qualities of 45 degrees in vernacular roofing are mythological and may safely be ignored. Harding goes on to note that the superstructure of Pimperne-type houses can be discerned with some confidence on the basis of ‘just two reasonably well supported inferences’ (Harding 2009a: 209-10). Perhaps not.



Conical roofs are the assumed norm

**Figure 41 (left) Skeuomorph of a Villanovian House from the Alban Hills, Lazio, in the British Museum collection. © The British Museum**

for British circular prehistoric and early historic structures. However, where contemporaneous or near contemporaneous Iron Age representations of circular structures

survive, we find that these have ridge poles from

**Figure 42 (right) Skeuomorphic house-shaped cinerary urn from southern Germany on display in the Charlottenburg Museum, Berlin.**



which short rafters reach out to the circular wallhead.

It is imagined that the ridgepole is supported on a central ring-beam structure. The house shaped cinerary urns of the Villanovan Period, 900-800 BC

illustrated in Figure 41, comes from the Alban Hills, Lazio. Similar urns, of the same period from southern Germany display many of the same features (Figure 42).

Villanovan houses are often oval, or rectangular, but the ceramic and bronze representations seem to relate to purely circular house-types. Images of Dacian and other native houses on Trajan's Column reveal simple curvilinear roofs<sup>87</sup> of the type which are known in post medieval Scottish vernacular architecture as 'creel roofs' used on creel houses, i.e. structures built by weaving withies together and coating the resultant basketry, or 'creel' in turves or daub and then thatched (see Dodgshon and Olsson 2006, 26, for a note on their requirement for some 2000 saplings per roof in the eighteenth century). There is no reason to assume that a viable broch roof could not be made by the same process. It is not the purpose here to establish that one solution or another is better fitted to current presuppositions about the roofing of brochs, it is merely to show that several options exist and that our adherence to conical roofs is as zeitgeistic and, unnecessary as they are impractical. In addition, the exposure at significant height of a further 3.5 to 7.5 m high conical roof incurs additional problems from quite severe wind force in addition to the fundamental difficulty of disposing of rainwater from the roof's catchment area.

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<sup>87</sup> It may be argued that circular or oval houses were not the norm in the Villanovan and other cultures, but they were the forms selected for representation in the cinerary urns and indeed on Trajan's column, which implies their common occurrence. In any event, the point at issue here is the clear technical competence of Iron Age builders to produce a ridgepole roof on a circular house.



If the gaming piece excavated by Niall Sharples at Scalloway is indeed a representation of a broch, as is suggested here, then the pattern incised into its upper surface (Figure 37) may represent the panels of an essentially flat roof (Sharples 1998, his Fig 113). Similarly, if the carving on Sueno's stone is representative of a broch, this also is a frustum of a cone in shape (Figure 37, right). Thus, both possible artistic representations of brochs appear to represent truncated cones without conical roofs and while this is a tenuous line of argument, nonetheless these objects had the potential to refute the non-conical hypothesis and they do not do so.

In the illustrated RSM (Figure 36), scarcement ledges that are level with the innermost lintel of the entrance passage, the commonest occurrence, are treated as supports for a floor. Their role as floor supports is supported by the existence of door-sized wall openings immediately above them, including one at Dun Gruagaig, that now provides the only access to or from the wall voids per SM2012.

The high scarcement at Dun Telve (9 m above the solum) is assumed, quite reasonably, to be a primary feature of the monument, and may have played some part in its roofing, even if only to provide a high-level framework from which the roof could have been built or supported. However, as implied above, the many and varied suppositions and debates on the nature of the roofing of brochs are all speculative in the absence of relevant evidence. The generic conical roof is the least probable and the most problematical of them all. Armit's account of Hope's suggestion that the roof was conical and sat within the outer wall and atop the inner wall has little to commend it (see discussion on page 261)

## Chapter 4 The Revised Standard Model (RSM), some consequences

### Introduction

Hypothesizing the existence of a canonical broch tower, a review of the extant literature has indicated the scope of SM2012 and the need for its revision (see Chapters 2 & 3). The revised standard model, (RSM) is introduced here and the concept is further developed in Chapters 5 & 8, where some of its implications are considered and the social contexts of the construction of RSMs are explored in Chapter 9.

Accepting for the moment that the RSM was the canonical form of the broch tower, it proves useful to consider its implications for the processes of building the broch, for the decomposition of the monument over time and for the nature of the evidence that survives to us. These issues are introduced here for their contribution to developing testable hypotheses derived from the research question, but the substantive discussion of their consequences are set out more fully in Chapters 8 & 9.

### Brochs as construction projects

For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it?ø King James Bible, Luke 14:28

The actions and processes involved in building a significant structure like a broch are directly paralleled in modern project management. A project is characterised as<sup>88</sup> being temporary, with defined start and end, unique in some way, having specific objectives, being the cause and means of change, involving risk and uncertainty and involving the commitment of human, material and financial resources. The informatic set out in Figure 43 (after Smith 2002b, 4) represents the

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<sup>88</sup> These characteristics of projects are drawn from the definitions of project provided by the Project Management Institute of the USA, 'a temporary endeavour undertaken to create a unique product or service'; and the BS Institute, UK; 'a unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or organisation to meet specific objectives and defined schedule, cost and performance parameters.'

stages in a typical project lifecycle. It has been modified here to a framework relevant to prehistoric building processes. In essence the build sequence is initiated by social demand operating upon and through a suitably wealthy local potentate who researches the costs and resource requirements in an appraisal phase. A particular design having been agreed with the technical designer, building can commence. On completion the structure is taken into the commissioner's ownership and occupied for the purposes and functions s/he intended. As a drystone structure it will have required a degree of maintenance and repair from the commissioner. Following abandonment, the structure may be re-formed, perhaps incorporating elements of the original, but if a full rebuild is required, the cycle would simply be repeated. The anachronistic terminology of the decision making tree on the right of Figure 43 reflect contemporary practice but clearly, *mutatis mutandis*, is applicable in prehistory also.

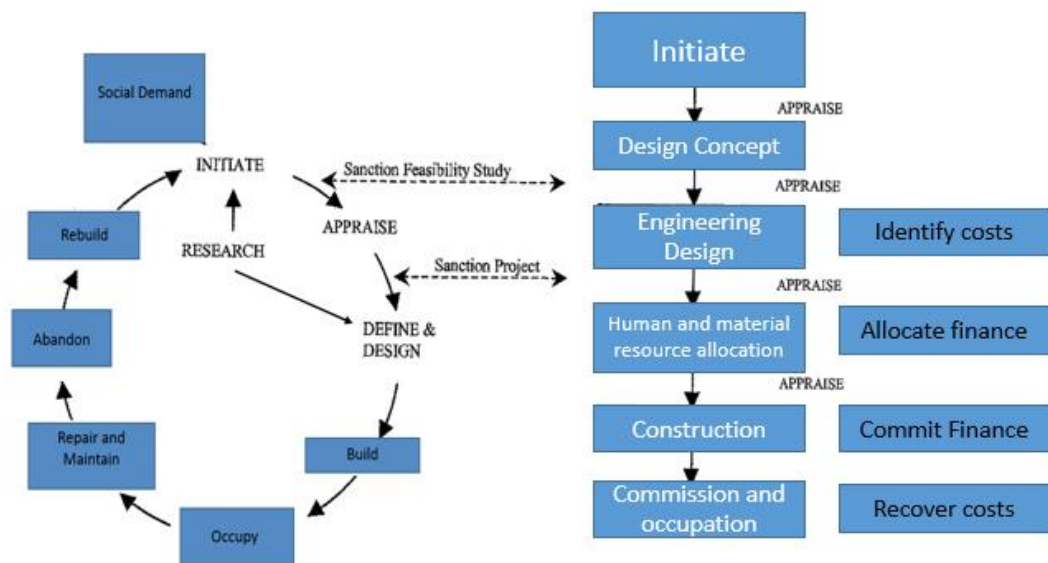


Figure 43 Project workflow diagram (based on Smith 2002b, 4)

## Social demand; vernacular or 'polite' buildings

The social context provides the initial stimulus for building, whether the structure was intended for defence or for *monumentalising* or aggrandising, for religious functions, or simply, as a home for a farming family (these matters are discussed above in 'A historiography of brochs' Chapter 3). The SM2012 zeitgeist is conveyed

by the Braby illustrations of a farming family living within a broch equipped for their convenience (see Figure 26). Within this context it is paradigmatically assumed that the broch was a vernacular build, probably on a par with an Amish barn raising<sup>89</sup>, in which several local families combine to complete the construction. In his work on the vernacular buildings of Shetland, Tait cites a dictionary definition of vernacular architecture as

‘the common building style of a period or place’ (Tait 2012, 3).

Tait adopts this definition, as well as the suggestion that vernacular architecture is synonymous with ‘folk architecture’ in support of which he also cites Brunskill’s suggestion that a vernacular building:

‘... will have been designed by an amateur, possibly the occupier of the intended building; he will have been guided by a series of conventions built up in his locality. The function of his building would be the dominant factor, [aesthetics] being quite minimal; local materials would be used as a matter of course, other materials being chosen and imported quite exceptionally.’ (Brunskill 2002, 28 as cited in Tait 2012, 3).

However, Brunskill (ibid) takes a much more catholic view of the vernacular, including in the text cited by Tait, multi-storey buildings with elaborate architectural detailing as well as industrial structures and a category of ‘urban vernacular’. The differences between Tait and Brunskill may in part reflect the difference between rural and urban vernacular but Brunskill is happy to include structures that have been designed by architects and built by commercial construction companies. Both agree that local construction capacity, use of mainly local materials and the emergence of local traditions of building characterise their rather disparate vernaculars. Tait’s definitions and his reading of Brunskill’s definition of ‘vernacular’ are accepted here.

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<sup>89</sup> Amish wooden barns are highly standardised and to some extent pre-fabricated by a group of neighbours. Its erection is supervised by a ‘master carpenter’ and may be completed in a single day; all the necessary resources having been provided by the farm on which the barn is built or gifted from family and friends.

The antithesis of vernacular structures is termed 'polite architecture' and its products almost invariably are created with the help of an architect, designer or master mason. However, the boundaries between these classes are blurred by the fact that many 'polite' but quotidian structures have been designed by architects on the basis of traditional designs of the area. The works of Laurie Baker, in India (Jain 2010) and Hassan Fathy, in Egypt (Fathy 1973, Steele and Fathy 1997) blur the boundary further, in that each designed using local materials and adhered to local building traditions mainly for reasons of environmental economy and for cost control to bring beautifully designed structures within the reach of the lower middle classes in both countries. Baker's work on brick-built vaults brought a very modernist feel to his structures, despite his use of traditional building materials. Whilst both produced excellent buildings, neither managed to achieve the market penetration they espoused and neither dealt with the issue of quotidian housing. It is possible that one reason for their failure was that theirs were not vernacular buildings in the strict sense. Unlike Brunskill, this writer believes that the active engagement of the non-professional local designers and builders and of the local community in general are preconditions to a successful vernacular tradition and in this, he finds himself in agreement with Tait's approach.

Influenced by Baker, Fathy and others, many architects now study the environmental accommodations of vernacular structures to local conditions around the world (see papers in Weber and Yannas 2014, especially the Santorini study by Stasinopoulos 2014). Inspired by a reverence for things past architects now ponder vernacular traditions as models for sustainable design (Forster, Heal *et al.* 2014).

However, vernacular does not imply unchanging, and Asquith *et al* strongly suggest that it constitutes a dynamic equilibrium rather than a static tradition:

‘Vernacular architecture should be explicitly treated as a cultural process rather than as merely a material product. Vernacular traditions are dynamic and generated through a continuous and dialectic interplay of stasis and change, precedent and creativity, stability and innovation.’ (Asquith and Vellinga 2005)

Tait, who may not share that view, nonetheless identifies an 'evolutionary' sequence, a typology of 12 types of farmstead within the vernacular inheritance of Shetland (Tait 2012, 186-221). Estyn Evans, in his ethnography of the Irish countryside implied that at the opening of the 20<sup>th</sup> century, an observer informed on the vernacular styles of housing, especially patterns of thatch, farm equipment and so on, would have been able to identify which parish s/he was in, based only on those parameters (Evans 1957). Vernacular architecture, *sensu* folk architecture, is characterised by its local and regional variations as well as by its variations over time. If then, broch towers were the products of a vernacular building process, it may reasonably be anticipated that strong regional and temporal variations may be discerned in the surviving remains and this is simply not true.

Conversely, if brochs are not vernacular, it must be accepted that some level of technical expertise existed in the larger population. The social contexts of that expertise merits consideration. In exploration of those social contexts two approaches are followed here; firstly, an abstract economic model is developed that is appropriate for rural communities in pre-coinage social hierarchies and secondly, the universals derivable from early Irish literature are considered as exemplifying the proposed model.

In describing remote communities at the dawn of history Alex Woolf drew upon the social model of 'farming republics' recorded in outlying Scandinavian territories, like Småland. These seem not to have had institutional 'kingship' before the end of the tenth century, and even then only in acknowledgement of the overlordship of the kings of the Danes (Woolf 2007; 49-50). Woolf describes the farming republics as 'self governing' dominated by very fluid and unstable chieftaincies. (ibid, 50) and suggests that a comparable social system may have continued in use in the Outer Hebrides into the later 900s (Woolf 2007; 298-300). Similarly, in explaining the third century geographer, G J Solinus's accounts of early third century life in the Western and Northern Isles, Fraser suggests that the 'flat-pack' societies described by Solinus were in fact Woolf's 'farming republics' (Fraser 2009; 34). Farming republics continued in existence even after the accession to kingship of Bridei, son of Maelchon, the sixth century Pictish king, of whom Adomnan's account in the *Vita*

*Columbae* implies that he held hegemony over large areas of Scotland, but perhaps not direct rule (Anderson and Anderson 1961; 85 *et seq*). That hegemony no doubt extended over many farming republics of varying scales. Fraser identified the later Bridei, son of Der-Ilei, who inherited in 696/7 AD, as the first powerful king of northern Britain to enter historical narratives, but acknowledges that even his rule was a suzerainty rather than rule by direct authority; his was an empire of many units that may have included

‘ a handful of major kingdoms í along with a large number of smaller autonomous units, including ‘farmer republics’ (Fraser 2009; 262).

The historians’ understanding of the social structures immediately before the emergence of ‘kingship’ indicate a fluctuating system of social control in the hands of small and autonomous but not clinically independent ‘chieftains’ of farmer republics. The persistence of farmer republics into the period of emergent kingship indicates the possibility that they were, at any given time, geographically circumscribed but never socially isolated and could be incorporated within larger political units and social entities, without loss of identity, at least for a time.

The commissioning agent for broch building is likely to have been the ‘chieftain’<sup>90</sup> or the leader, *pro tem*, of a farming republic at a time before institutional or hereditary rulers had evolved, locally.

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<sup>90</sup> The term ‘chieftain’ is used here solely to mean the leader of the community group under consideration. JD Hill (Hill, J D (2014). "How Did British Middle and Late Pre-Roman Iron Age Societies Work (if they did)?" DOI 10.1093/acprof:osobl/9780199567959.003.0010; 07\_02\_2017: see also Hill in Haselgrove, C C (2006). *Les mutations de la fin de l'âge du Fer : Celtes et Gaulois, l'Archéologie face à l'Histoire, Actes de la table ronde de Cambridge 7-8 juillet 2005*, CAE européen Mont-Beuvray (1 Jun. 2006).). Hill argues that Iron Age society was not hierarchical, in the sense of mapping wealth and or power onto a triangular form with a single apical lead figure; a king or chieftain. but instead presents a range of parallelogram forms as possible alternatives. It is not always clear what Hill intends to convey but he seems to indicate that the conventional social pyramid is not relevant to the Iron Age, albeit that he does not say why this is so. However, he seems also to believe that the alternative to a complete social pyramid is no pyramid at all and this is perhaps simplistic. The farming republics described by Woolf and Fraser (above) can be understood in terms of groups of agricultural estates, each with its familial or other leader and amongst these *pares*, at any given time, there is one who is *primus inter pares* and under whom stretches a social hierarchy, albeit one with only a few classes. It is hard to conceive how these farming aggregations can enter alliances or servitudes with emergent regional and or institutional rulers in the absence of a spokesperson. In the

An economic model is presented below that purports to model the social context of emergent wealth creation and curation in rural, pre-coinage societies. Binchy's definition of Early medieval societies as tribal, rural, familial and hierarchical (Binchy 1954, 54) is rooted in his studies of early Irish literature (EIL). No unambiguous contraindications to his definition can be found within the Iron Age archaeological record, with the possible, but improbable exception of the village-like structures surrounding eastern and northern brochs, but use of EIL is considered further below.

Whilst the EIL has been used uncritically to characterise the whole of the Iron Age, the following economic model is based only on the universals of wealth generation and curation in non-urban, pre-coinage societies. It is possible to characterise the economics of such rural communities as follows:

- i) The economic engine was agriculture, with yields divisible into two elements, subsistence and surplus.
- ii) The subsistence element fed the community's population.
- iii) The surplus element comprised the excess of food supply over demand<sup>91</sup>.
- iv) The surpluses could underpin population growth, but land carrying capacity and biological limitations constrained the rate of population growth.
- v) As rural settlement was also dispersed, Iron Age population growth generally remained below the threshold required for the development of urban centres except, perhaps, in the eastern and northern part of the broch distribution and in hillforts and their cognates elsewhere.
- vi) Animal and crop surpluses have a limited shelf life albeit that the surplus animals could be retained in the domesticated herds, but only until the capacity of the Chieftain's landholding to sustain the herd over winter was reached.
- vii) Deepening of the hierarchical social structure provided a way of retaining surpluses. A Chieftain could appoint a number of aristocrats who in turn could appoint further subsidiary clients to whom agricultural equipment and cattle were given, by the Chieftain to the Aristocrat and by him/her to the clients, each in return for a share in the subsidiaries' future surpluses, and probably

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absence of an external or imposed kingship -peakøto their social pyramid, there were no doubt individual claimants to the right to speak for all, but these are unlikely to have spoken for many beyond their own immediate locality.

<sup>91</sup> The subsistence element equates with the profit and loss account and the surplus element with the profit generated by the production/consumption process as negotiable wealth, which ó in modern economic terms - can accumulate, as a capital reserve in the balance sheet value of the community



also to the provision of labour and other services<sup>92</sup> (see Charles-Edwards, Stacey *et al.* 1993).

- viii) The aristocrat could then retain ownership of a growing herd whose provender and husbandry was provided by his/her clients who in practice became sharecroppers, just as the aristocrat became a sharecropper of the Chieftain.

The social glue that held these communities together was the management of cattle herds on contract from those higher up the aristocratic scale. Failure to meet the obligations of this quite explicit social contract would result in relegation to lower status. The social contexts portrayed in the EIL reveal just such an economic model and the social configurations of relationships and legislation that evolved to manage life within it. Early Irish Literature, which has been characterised as ‘a window on the Iron Age’ by Jackson in his eponymous Rede Lecture (Jackson 1964). Reliance on the EIL, especially on the Ulster Cycle of tales, for insight into the nature of early Iron Age society has a long history, which Mallory has explored in depth (Mallory 1992b, 103-111). He traced a history of scholarship, focussed on the Táin, and leading from Seathrún Céitinn’s *Foras Feasa ar Éirinn* in c 1634, through O’Curry 1873; Pflug-Harttung 1892; Joyce 1903; Ridgeway 1906; Dobbs 1913; Bauersfeld 1933; Powell 1950; Jackson 1964 and Hamilton 1968 to Olmstead’s view that the Gundestrup Cauldron imagery represents some form of archetypical rendering of the events of the Táin (Olmstead 1976, Olmstead 1992). Jackson summarised the argument and presented a reasoned case for seeing the Ulster Cycle as formed from fragments of a much earlier oral tradition (Jackson 1964, 55) upon which scholars could rely for insight into earlier social organisations and practices.

In response, archaeologists in the British Isles and elsewhere have continued to consciously or unconsciously use the Ulster Cycle as a basis for the formation of paradigmatic assumptions about Iron Age society<sup>93</sup>, many latterly founding or re-founding on Jackson. A completely antithetical position was initiated by McCone,

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<sup>92</sup> This was a capital investment with interest-only repayment and retained ownership of the assets.

<sup>93</sup> Halligan suggests a tradition had already developed about the tradition of the Ulster Cycle by the 19<sup>th</sup> century (Halligan, B (2015). *Wonder, Wisdom and War: essays on early Ireland*. Dublin, Scathan Press.)

for whom the Ulster Cycle was cut from whole cloth in an Irish monastery probably in the second half of the first millennium AD (McCone 1990). McCone's work is strongly polemical and staunchly anti-nativism, i.e. against the view that native Irish life has anything much to do with the stories compiled in Early Irish literature<sup>94</sup>.

Mallory wrote of Renfrew's foray into the linguistics and origins of the Indo Europeans, that Renfrew had 'put his pigeon amongst the cats' a reference to the *ad hominem* and unpleasant tenor of a significant amount of the Early Medieval Historian's *oeuvre*. John Carey, in his review of McCone (Carey 1992) suggests that McCone's work is of this type and that his commentary on O'Rahilly could with justice be redirected to McCone himself, viz:

The end result of this intuitive eclecticism is an erudite but alarmingly capricious and idiosyncratic treatment that continues to cast a steadily fading shadow over sections of early Irish studies. (McCone 1990, 57)

It is not easy to disagree with Carey in this instance.

In essence, McCone proselytises the view that the content and structures of the several works that comprise early Irish literature are confections created by monks that thinly veil biblical stories and Christian morality in a newly created (7<sup>th</sup> or 8<sup>th</sup> century AD) historical narrative based on a conception of pre-Patrician life. It is not clear who the audience for these opaque metaphors and parables might have been nor is it clear how this 'conspiracy' was disseminated amongst the several and distinct authors involved in it.

A good deal of the ongoing debate amounts to little more than assertion and counter assertion, and while much of it is interesting, no convincing resolution is in sight.

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<sup>94</sup> The poet, Matthew Arnold discussed comparable issues in a book of his essays published in 1910, in which he distinguishes between anti-philocelts, who repudiated the romanticised and fictional lovers of invented 'Celticity' and the anti-celts, who for reasons of ignorance or simple bigotry, rejected populations then identified as 'Celtic' however defined. (Arnold, M (1910). *On the study of Celtic Literature and other essays by Matthew Arnold*. London, J M Dent & Sons.). *Plus ça change*.

The literature is finite and is unlikely to yield unambiguous new evidence to support or refute either side. Jim Mallory purports to show that objects described in the Táin and recoverable by archaeological excavation are mostly, he asserts, of Early Medieval date (Mallory 1992a) and support the McCone position. However, even if he were correct, it should be expected that the details of the Ulster Cycle would naturally reflect the cultural *milieu* within which it was committed to writing, whether the story is based on oral traditions or freshly created as a historical novel drawing its inspiration from the Roman works of Posidonius and those who cite or plagiarise his work, including Timagines, Julius Caesar, Diodorus Siculus and Strabo (Edelstein and Kidd 1972).

Aitchison dismisses Jackson's reliance on Caesar's description of the Gauls as an inadequate simile with which to bolster his, Jackson's, support of an oral tradition as the primary source of the Ulster Cycle (Aitchison 1987). However, the narrative models of the social contexts of the protagonists of the Ulster Cycle are consistent with the Roman accounts of the Gauls and it is highly likely that some at least of the Roman sources would have been known to Early Medieval clerics<sup>95</sup>. This may explain the consonance of the Cycle's view of the social context of the stories with that of the Roman sources. Indeed, the arch anti-nativist McCone suggests that

— a number of considerations suggest that at least some aspects of this legal theory and practice have roots in the pagan Celtic or even Indo-European past (McCone 1990, 84).

This quotation is not far removed from Binchy's suggestion that some scholars

— are perfectly right in their main thesis: that Irish Law preserves in semi fossilized condition many primitive 'Indo-European' institutions of which only faint traces survive in other legal systems derived from the same source. (Binchy 1943)

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<sup>95</sup> The use of *De Bello Gallico* as a teaching aid for students learning Latin remains a constant to this day, largely because of its lucidity and grammatical consistency.

Similarly, whilst Aitchison decries the use of the Táin to explore the pastoral nature of the Irish economy, the importance of cattle and the violent nature of society, he also acknowledges that the Irish Annals reveal cattle raiding in the early medieval period and he cites Lucasø 1989 work on *Cattle in ancient and medieval Ireland*, which significantly undermines Aitchisonø's own point in respect of pastoral economy and the use of cattle as a unit of value (Lucas 1989). He might also have cited Lucasø's enumeration and analysis of some 900 raids, variously of Irish and/or Norse against Irish and/or Norse recorded in the Annals, as a gauge of the violence in society over the period AD 615 to 1546 (Lucas 1967, 172). Any doubt remaining on the rural setting and importance of cattle in Early Irish society can be resolved by reference to Kellyø's work on Irish farming in the 7<sup>th</sup> and 8<sup>th</sup> centuries, deduced from the law tracts of that date (Kelly 2000, 6-9 and passim).

It is argued here that whether the Ulster Cycle finds on oral tradition or on Roman originals, the outcome is a narrative that has relevance to Iron Age settlers in these islands. Indeed, if the Ulster Cycle finds on Roman texts, then its value as a palaeo-ethnographic<sup>96</sup> study of the first few centuries BC/AD is potentially all the greater. The pastoral nature of the rural economy, the value placed on cattle and the internecine warring of competing families, regions and tribal associations are all well attested in the early medieval period.

The question remains, of course, of how relevant these may be as a simile or analogy for life in the Iron Age. It would be naïve in the extreme to use the Ulster Cycle as some sort of universal template for all matters -Celticø in these islands given that

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<sup>96</sup> The writer has eschewed the use of ethnography and particularly of archaeologically based ethnographic parallels because of the underlying colonial biases that permeates most British and Western European writing on the subject. Even in rejection, those biases generate an unacceptable level of condescension to peoples who live non-industrialised life styles.

much of its context, colour and detail must necessarily derive from the context of its commission to writing<sup>97</sup>.

In seeking to derive from early Irish literature some indication of the nature of earlier society, it is clearly necessary to focus on universals and to avoid where possible detailed but non-universal descriptions and attributions. It is postulated as fore-knowledge that in emergent hierarchies, the necessary accumulation of relative wealth and the power, must rely directly on the commodification of food surpluses in the absence of cash or a cash equivalent. Fundamental rural economics persisted in the Iron Age and in the early medieval periods and are thus universal to both situations. The EIL illustrates the consequences for social organisation of the commodification of food surpluses and their treatment as revenue and capital and this is discussed further in Chapter 9. To the extent therefore that the analogy drawn here relies on this universal fore-knowledge and on the universals of the EIL, it is argued here that hierarchies founded on rural economies will, generally and necessarily, be similarly structured and, with restraint, may be compared with each other.

In dispersed populations living in small settlements it is inevitable that some level of craft skill was available even at the household level. The relevant skills might

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<sup>97</sup> It is useful to consider here the issues of universals (from *Metaphysics*) and predicables (from Aristotle's logic) both of which contemplate the issue of categorisation. MacLeod and Rubenstein suggest that:

∃Universals are a class of mind-independent entities, usually contrasted with individuals (or so-called "particulars"), postulated to ground and explain relations of qualitative identity and resemblance among individuals. Individuals are said to be similar in virtue of sharing universals.∅(MacLeod, M C and E M Rubenstein (N/S). Universals. The Internet Encyclopedia of Philosophy. J. Fieser and B. Dowden. )

Conversely, Aristotelian logic founds on the concept of predicables, or of qualities predicated upon the subject of a syllogistic sentence, thus in ∃All men have two legs∅ the quality of possessing two legs is predicated upon all men. However, the logically flawless syllogism ∃All men have two legs; Socrates has two legs∅and therefore Socrates is a man∅is violated by men who have one leg, or none, or by ostriches called ∃Socrates∅ This loss of logical sense can be attributed to the fact that possession of two legs is not a universal for the entity ∃all men∅(see Smith, R (2016). Aristotle's Logic , , forthcoming The Stanford Encyclopedia of Philosophy (Winter 2016 Edition). E. N. Z. (ed.). for wider discussion of Aristotelian logic).

include house building, blacksmithing, weaving, stone walling, and so on. To this day, Circuit Court jurists in Britain and Ireland continue in a peripatetic tradition<sup>98</sup>. Senior Iron Age jurists were no doubt called upon to service the needs of dispersed communities from time to time. However, it would be hard for a simple peripatetic model to produce the extraordinarily high level of skill exhibited in some crafts. The metalworking skill required to produce for example a Gundestrup cauldron (Nielsen, Andersen *et al.* 2005) or indeed any cauldron, is unlikely to have been acquired by autodidacts working in relative isolation. As their accomplished creations demonstrate, centres of excellence must have existed, presumably at high status settlements, in which the availability of patronage and the interactions of master craftsmen fostered the development and curation of skillsets and experience. The vast sea of evidence from excavations in advance of new roads in Ireland has identified a tripartite element in Early Medieval settlement. Bhreathnach suggests that:

‘[is] a pattern [is] now emerging throughout the countryside of settlements with associated familial cemeteries and a range of industrial activities including milling, metal-, and woodworking and butchery.’ (Bhreathnach 2014, 19).

Some of these estate farms, for such they are, would have provided the centres of excellence from which higher level skillsets could be disseminated into the population when required, and no doubt at a fee. The medieval ‘expertise’ a meeting of experienced master masons convened, for example, on a new cathedral site, to discuss the complex issues of roofing the building may well be the successor to this tradition (Coldstream 2002, 65).

It can readily be imagined that at some such centre a master mason created the first broch, possibly following some initial failures, and then disseminated the concept throughout his/her peers in the north of Scotland and the islands. The quality of the

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<sup>98</sup> See, for examples Irish Circuit Courts, and their equivalents instituted in the UK in the twelfth century by King Henry II.

masonry at well preserved brochs has no equal in drystone building in Scotland and construction to this QA standard would also have been a transferrable skill devolved from a centre of excellence. Given the complexity of the broch form and the engineering sophistication of its diagnostic substructures, it is not credible that these skills arose by parallel evolution from a diverse vernacular architectures of the area of the broch distribution, none of which display the key features, even in rudimentary form.

## Stone, timber and cordage

Having secured the services of an appropriate professional, and some master stone masons to leaven the locally available skillset, the next challenge would have been the securing of the necessary resources. These would have included iron and stone tools, quarried building stone and its transportation, human and probably animal



**Figure 44 The toolkit of the 19th and 20th century quarrymen of Caithness; displayed in Castletown Museum. Nothing in this assemblage could not have been in existence and use in Iron Age Scotland.**

traction, together with cordage and timber. Sedimentary stones, common in the NE Mainland and Orkney, were easily quarried. The tool kit of a quarryman in the early 20<sup>th</sup> century had not advanced over that which could have been available to his Iron Age ancestor (Figure 44) for the working of stratified sedimentary flagstones.

The promontory fort at Nybster has a rock-cut ditch (Figure 45) and while tool marks are not readily visible on the photographic image, they were observed in the field (I am grateful to my colleagues Drs Cavers and Heald for this information). However, the bulk of the quarrying may have been undertaken using stone tools. The

face visible in Figure 45 was quarried by use of heavy mauls that leave a stepped profile<sup>99</sup>.



**Figure 45 The rock cut ditch at Nybster. The use of stone pounders for quarrying militates against the production of vertical faces and the sides of the Nybster ditch steps out towards its centre line as it descends. Not a disadvantage in ditch digging, it can be a severe disadvantage at a quarry face. © AOC Archaeology Group**

Quarrying volcanic and metamorphic stone, on the other hand, cannot ever have been easy. Observation of quarrying of both stone types, and discounting mechanisation of the processes, it

seems to the writer that quarrying hard-rock types requires significantly more effort and energy than quarrying sedimentary stone. No experimental work has yet been done on Iron Age stone quarrying. Indeed, more is known about quarrying in chalk for flint in the Neolithic<sup>100</sup> (Renfrew and Bahn 2001, Bradley 2007) and for copper

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<sup>99</sup> The efficacy of stone tools for quarrying stone need not be in doubt, even for very hard rock stone-types. In excavation of the chambered cairn at Borralan East (c. 3800 BC), made from a granitoid hard-rock, the writer discovered a new category of stone tools, used in quarrying and working, including surface dressing of the granitoid slabs (Barber et al). These tools were fashioned from a re-metamorphosed quartzite of extraordinary density and hardness and had not previously been noted in archaeological contexts.

<sup>100</sup> Neolithic flint mining was carried out on an industrial scale with, for example, some 350 shafts of 9 m depth, with associated galleries at Grimes Graves alone. Renfrew and Bahn (2001, 315) note the existence of flint mines at Grimes Graves in England; Spiennes, in Belgium; Krzemionki in Poland



and tin ores in the Bronze Age. Extensive experiments have been undertaken in the quarrying of both hard-rock and softer rock types in Egypt. The use of copper and bronze tools to quarry and work stone is widely attested, but so is the continuing use of stone tools, especially to quarry hard-rock types. Using metal tools required the presence in the quarry of quite extensive metal working areas in which repair and maintenance took place and in some of which, metal residues in the quarry waste were recovered and recycled (Stocks 2004 Part I, Chapters 1 to 3). If the Egyptian experience may be considered a generic guide, it suggests that in future a geophysical check for metalworking sites might help guide archaeologists to the quarry sites for individual brochs. In addition, erratics or manuports, rock types alien to the local environment should all be checked for use-wear, to assist in identifying stone quarry tools.

Some metamorphic stone types can exist in a tabular form, e.g. some Lewisian Gneiss facies (see Illus 135-g, in Romankiewicz 2011, 100; for example) and some preserve echoes of their laminar pre-metamorphosed sedimentary origins. While some sedimentary rock types are as dense and as hard as volcanic and metamorphic types, such as the Torridonian sandstone of Clachtoll (Appendix Clachtoll) in general the volcanic and metamorphic hard-rock types are less favourable for building with than any of the sedimentary stones. Conversely, Orcadian and Caithnessian flagstones have cleavage planes at 30, 60 and 90 degrees (Figure 46) that together Iron Age. Coppicing of trees like hazel or willow<sup>101</sup> would have met part of the demand, and no doubt wattle screens were more commonly used than planking, even in areas in which timber was more readily available. The writer's excavations at Clachtoll have revealed the use of wattle screens in brochs (Appendix Clachtoll). Woven from withies derived from coppiced species, such as willow, which exist now with their regular cross sections and parallel faces make them ideal building material.

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and Rijckholt in the Netherlands: to which Bradley (2007, 37) adds sites in Southern Sweden, Denmark and northern France.

<sup>101</sup> *Corylus* or *Salix*, resp.

The requirement for timber in the build and fit out of the SM2012 broch would have posed problems because throughout most of the Atlantic Zone trees of any height or scantling are now rare in the landscapes of the broch and probably were as rare in the and probably existed throughout the Iron Age Atlantic province, their production does not need us to assume forest cover.

However, the demand for substantial timbers could not be evaded entirely. Drift wood is often cited as the source of large timbers (see Dickson 1992 for Scottish west coast, but see Johanson 1999 for more informative study of equivalent Norwegian phenomenon). Adomnán recounts an episode in the seventh century *vita* of St Columba, in which the saint miraculously eases the burdens of monks who faced adverse winds while at sea in twelve currachs, or skin covered boats, towing oak timbers from the river Shiel<sup>102</sup> south-westwards to Iona (Anderson and Anderson 1961, 454). The irreducible demand for substantial timbers could have been met by maritime transport, without reliance on the uncertain supply of flotsam from the



**Figure 46 Typical Orcadian bedrock exposure of flagstone formation with (here) horizontal bedding planes and vertical cleavage planes at 30, 60 and 90 degrees to each other. This produces first class building stones with minimal quarrying cost.**

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<sup>102</sup> Forms part of the boundary between Inverness-shire and Argyle-shire

Americas (see Fojut 2005a<sup>103</sup> for further discussion and, on his page 196, for calculation of the numbers and types of beams required for 4 types of internal and



roofing arrangements).

Cordage must have been in universal daily use during the Iron Age but it rarely survives on sites or monuments. Crone has reported cords of Hairmoss and Willow withies, from

**Figure 47 Prehistoric remains of fish traps preserved in the sands of the estuary of the river Fergus, a tributary of the River Shannon, Ireland; and (right) what they might have looked like when first built.**

waterlogged sites of the early medieval period (Crone 2000) and no doubt the few preserved remains under-represent a much larger volume and range of materials. Basketry would similarly have been a quotidian commodity of all prehistoric periods and is as poorly represented in the archaeological records, albeit that Hurcombe found proxy-evidence for basketry making in the use-wear of flint tools (Hurcombe 2009). Apart from use-wear evidence, only the accidents of preservation in anaerobic conditions, for example, of baskets in fish weirs sunken in riverine muds, demonstrate the existence of these technological competencies (Figure 47)

That cordage and basketry, together with some substantial timbers were available to the broch builder can be accepted with confidence. Sadly, it is less easy to determine what the load bearing capacities of these may have been. In addition to hair moss, there is evidence for the use in prehistory of other organic fibres, including human

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<sup>103</sup> Commenting on the fact that the timber requirement for brochs was estimated not on the basis of excavated or structural evidence, but on the conventional artist's impression of the internal arrangements in brochs, Noel Fojut, with characteristic humour entitled his 2005 paper 'Brochs and timber supply, a necessity born of invention'

hair, and of leather thongs; the latter sometimes being woven or braided into cables which could have been of considerable length and strength.

One timber demand ignored by many scholars to date is the requirement for scaffolding during construction. In general, it is conceived that the tall walls were built, helically in rises that approximate to the comfortable working range of a mason. Given the extreme thickness of the wallhead, the rise may have been somewhat short, perhaps as short as 500 mm. As noted in Chapter 3 (& see Figure 33) this scale and rate of build could have been managed from suspended scaffolding.

### **Bills of Quantities**

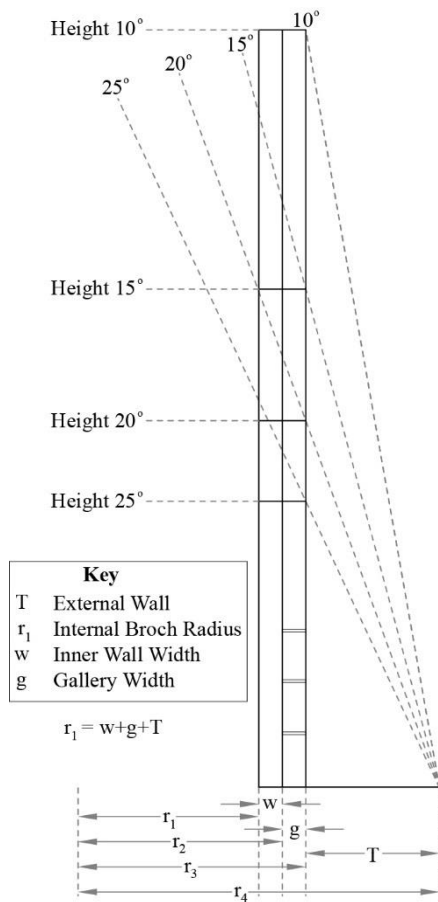
In arriving at an evidence led appreciation of the social costs of building a broch, it is necessary to estimate the quantities of materials used in the construction and the person-days required to manipulate that material in the building process. If broch building were a vernacular process with great variability in the form and scale of construction, it would be impossible to arrive at realistic estimates of the quantities used. Even if we suppose that brochs are canonical forms, great uncertainty remains and these are explored in Chapter 8.

A broch tower is a three-dimensional object and scaling in three dimensions is not a linear process<sup>104</sup>. Broch size is conventionally stated as one of its diameters, often its unreliable external diameter, and very rarely is any consideration given to the volume of the completed structure. However, the original commissioner of the broch would have needed to know the quantities, or at least the cost of their provision, assuming that s/he wanted to build a broch of a given size. While the quantities of iron tools, timber, cordage and basketry required for the construction project are currently unknowable, estimates of the volume of built masonry can be formulated for the RSM. Details of the formulae and calculations are contained in Appendix 4.1, q.v.

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<sup>104</sup> If the side length (L) of a cube is doubled (2L), its footprint is multiplied by four (2L<sup>2</sup>) and its volume by eight (2L<sup>3</sup>).

In calculating the volume of the RSM the standard parametric formulae for hollow right cylinders and circular truncated cones have been modified to use the internal radius ( $r$ ) and the slope angle of the outer wallface ( $\theta$ ) as the primary variables from



**Figure 48** Notation used in the calculation of convergence heights in Appendix 4.1

which  $h$ , the height is calculated and thereafter volumes and masses are derived from these three variables. The calculations are based on the following assumptions:

- i) The example considered throughout is a ground-galleried broch<sup>105</sup>.
- ii) The external radius is assumed to be  $2r$ , i.e. the wall thickness ratio is 50%.
- iii) The inner wall thickness ( $w$ ) is assumed to be 0.94 m and the ground-gallery width ( $g$ ) is assumed to be 0.93 m: the means of the available reliable measurements.
- iv) The outer wall is assumed to abut the inner wall at, or just under the wallhead, and to have approximately the same thickness as it, at the point of contact.
- v) The conjoined wall is believed to extend above the point of contact but since the height of this section is unknowable, it is excluded from calculation. Its inclusion would not affect their

<sup>105</sup> Ground galleried brochs allow the calculation of a generic formula. The alternative, to calculate the volumes of masonry where from one to five ground cells exist creates a proliferation of data with little additional gain, and where issues of structural stresses are considered, metrics of the exact positions, scale and form of the cells are required to make the analysis meaningful. This would require a separate analytical process for almost every broch. The reader can apply the formulae and spreadsheets from Appendix 4.1 to individual structures, adding calculations for the individual ground floor configuration. Research is currently underway to try to develop software that can process the variability of form for such individual monument analyses.

relative proportions of volume or mass between brochs.

- vi) The combined height of the ground floor and two lowest galleries is assumed to be about 6 m above the primary solum.

The outer wall's inner wallface corbels progressively over the gallery footprint from the top of the third gallery, occupying about one third of the projected gallery space above that level.

**Table 4.1 Table of convergence heights ( $H_c$ ) given external wall thickness,  $T$ , and angle of inclination  $\alpha$ . All linear dimensions ( $r$ ,  $T$  and  $H_c$ ) cited in metres; angles ( $\alpha$ ) cited in degrees. The red shaded italic numbers are the corresponding internal radii ( $r$ ).**

**T, the outer wall thickness less the inner wall thickness at ground level.**

<b>T</b>	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6	9.1	9.6
$\alpha^\circ$	<i>3.5</i>	<i>4.0</i>	<i>4.5</i>	<i>5.0</i>	<i>5.5</i>	<i>6.0</i>	<i>6.5</i>	<i>7.0</i>	<i>7.5</i>	<i>8.8</i>	<i>8.5</i>	<i>9.0</i>	<i>9.5</i>	<i>10.0</i>	<i>10.5</i>	<i>11.0</i>	<i>11.5</i>
10	9	12	15	18	21	23	26	29	32	35	38	40	43	46	49	52	55
11	8	11	14	16	19	21	24	26	29	32	34	37	39	42	44	47	50
12	8	10	12	15	17	19	22	24	26	29	31	34	36	38	41	43	45
13	7	9	11	14	16	18	20	22	24	27	29	31	33	35	37	40	42
14	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39
15	6	8	10	12	14	15	17	19	21	23	25	27	28	30	32	34	36
16	6	7	9	11	13	14	16	18	20	21	23	25	27	28	30	32	34
17	5	7	9	10	12	14	15	17	18	20	22	23	25	27	28	30	31
18	5	7	8	10	11	13	14	16	17	19	20	22	23	25	27	28	30
19	5	6	8	9	11	12	13	15	16	18	19	21	22	24	25	27	28
20	4	6	7	9	10	11	13	14	15	17	18	20	21	22	24	25	26
21	4	6	7	8	9	11	12	13	15	16	17	19	20	21	22	24	25
22	4	5	7	8	9	10	11	13	14	15	16	18	19	20	21	23	24
23	4	5	6	7	9	10	11	12	13	14	16	17	18	19	20	22	23
24	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	21	22
25	3	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21

These assumptions are illustrated in the RSM (Figure 36) and Figure 48 follows the notation of the spreadsheet Appendix 4.1, in which, the modified parametric formulae are applied to a range encompassing the more reliable recorded ranges of internal radii ( $r$ ), from 3.5 to 7.5 m and the directly measured batter-angle ( $\alpha$ ), from 10 to 25 degrees out of the vertical. The convergence heights ( $H_c$ ) are first calculated using  $r$  and  $\alpha$ , to provide the height of the wall convergence, listed in Table 4.1. The calculated tables of 9 ( $r$ ) values by 16 ( $\alpha$ ) values creates a data range for 144 possible brochs but additional values can be calculated using the formulae in the tables.

The calculated  $H_c$  ranges from 3 m to 32 m. The tallest surviving broch remains are estimated, variously, to lie between 12 and 15 m high at convergence and the estimated heights lying in that range are highlighted blue-grey in the table.

Monuments with convergence heights of 6 m or less cannot physically meet the parameters of the RSM because they fall below the height threshold from which the inward corbelling of the outer wall would begin. This is a design constraint: the design is not scalable below threshold values for  $r$  and  $\theta$  (see Table 4.1) mainly because the inner wall and the intramural void do not scale. In actual practice this would make it difficult, but not impossible, to build monuments less than about 8 to 9 m high. Those with  $H < 6$  m are shaded gold in the bottom left part of the table. Brochs where  $6 \leq H \leq 8$  m high are shaded in a lighter tone. The former are extremely unlikely to have ever been built while the latter are merely unlikely.

The dark blue-grey band (brochs 12 to 15 m high) sets an upper limit to the known maximum size of built brochs. The diagonal strip between the upper boundary of the unfeasibly small and the upper boundary of the largest known brochs is the range within which brochs could be built; on the available evidence the buildable range.

Proportion	Degrees	<b>Table 4.2 Rules of thumb (e.g. 1 in 2 to 1 in 6) used by masons and the corresponding batter angles, in degrees</b>
1/6	9.46	
1/5	11.31	
1/4	14.04	
1/3	18.43	
1/2	26.57	

The largest reliably measurable internal radius is close to 6.5 m, and so estimates for larger diameter brochs in Table 4.1 are probably irrelevant, but these very large brochs are at least theoretically buildable, on design grounds alone and their absence from the surviving corpus relates to the builders' decision not to build them; it is not an apparent consequence of the design of the model. The other tables in this sequence are provided only for the range 3.5 to 7.5 m which encloses the range of relatively reliably measured internal radii. The values of  $\theta$  lie between 10 and 25 degrees but it is very likely that the higher values represent deformation of brochs as they fell apart and a range of 10 to 18 degrees, or thereto, would probably be more reasonable.

Given that the outer walls of all except Mousa are linearly battered, the batter angle of the outer wallface was probably built by stepping back the wallface by 1 unit for every X units of rise. Here the integer fractions of 1 in 2 to 1 in 6 are tabulated against the batter angle in degrees. These approximately encapsulate the range measured in the field.

**Table 4.3 Total built volume (in m<sup>3</sup>) derived from internal radius (r) and the batter-angle of outer wallface ( $\alpha$  degrees) (see Appendix 4.1 for the formulae and calculations)**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		528	915	1433	2101	2936	3956	5179	6622	8304
11		473	824	1294	1899	2656	3581	4690	5998	7523
12		428*	748	1177	1730	2422	3267	4281	5477	6871
13		389	684	1078	1587	2224	3001	3934	5035	6318
14		356	628	994	1464	2053	2773	3636	4655	5842
15		328	580	920	1357	1905	2574	3377	4324	5429
16		302	538	855	1263	1775	2400	3149	4034	5066
17		280	501	798	1180	1659	2245	2948	3778	4745
18		260	468	746	1106	1557	2107	2768	3549	4459
19		242	438	700	1040	1464	1984	2607	3343	4202
20		226	411	659	979	1381	1872	2461	3158	3969*
21		211	386	621	925	1305	1771	2329	2989	3758
22		198	364	587	875	1236	1678	2208	2835	3565
23		186	343	555	829	1173	1593	2097	2694	3389
24		174	324	526	787	1114	1515	1995	2563	3226
25		164	307	499	748	1060	1442	1901	2443	3075

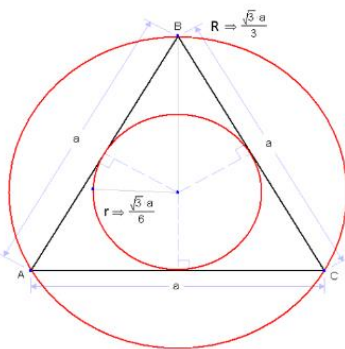
The volume of built masonry, in m<sup>3</sup>, is displayed in Table 4.3. The shaded areas in this table corresponds with those in Table 4.1. The shaded range includes steep-sided slender-walled towers, at the top left, and more gently sloping, thick-walled towers on the lower right side of the range. On each row, the smallest buildable broch (left hand column) is between 5 and 6 percent of the largest. The smallest buildable tower would have required less than 8% of the built volume of the largest in this table. Restricting the comparisons to brochs that were buildable and not taller than 15 m, the largest is 9.3 times the volume of the smallest (marked with asterisks in the Table



4.3). The significance of the calculated volumes for the construction of the broch is discussed in Chapter 8.

## Geometries of construction

The ancient and medieval practices of controlling the scale and proportion of a structure of standard form have been noted above (Chapter 2). In general, these rely on identification of a modulus of length and a simple rule-set governing relative proportionality. The distribution of internal radii measurements from brochs is approximately normally distributed, but only when values that lie more than 3 standard deviations from the mean are omitted. Regrettably, the imprecision of the bulk of the measurements regularly cited is too great to be founded upon for indications of an original modulus, other than the length of the internal radius, which also determines the length of the external radius.



**Figure 49** The radius of the incircle ( $r$ ) of an equilateral triangle is one half the length of the radius of the circumcircle ( $R$ ). (creative commons ©)

**Table 4.4** The incircle's radius length ( $r$ ) expressed as a percentage of the circumcircle's ( $R$ ) for regular polygons of 3 to 10 equal sides.

Polygon Sides	3	4	5	6	7	8	9	10
$r$ as % of $R$	50	29	19	13	10	8	6	5

The wall-thickness-ratio (see MacKie 1975) can be represented as the ratio of the incircle to the circumcircle of a regular polygon from which the broch's inner and outer radii could be derived (see Figure 49 for equilateral triangle example). Values for this ratio from the regular polygons of 3 to 10 sides, range from 50% for the triangle to 5% for a decagon (Table 4.4). If a simple geometric form underlay the

plan design of the broch, only the simplest, the equilateral triangle, would match the reported data.

### Surveying-in the ground plan

Euan Mackie suggested that his hypothetical standard broch based on Dun Troddan, would have had an external diameter of 18.36 m and a wall thickness of 4.59 m (MacKie 2002, 6). This is equivalent to a wall thickness ratio of 50% (the wall thickness is equal to the internal radius, so that external radius  $R=2r$ ). Taking the dimensions variously cited in his 2002/2007 corpus, the means of the external and internal diameters, 17.83 m and 9.45 m yield a ratio of 47% and an internal radius of 4.73 m. For all the reasons already discussed this is an unreliable result<sup>106</sup> but it is accepted here as indicating that something like 50% was probably the intended ratio.

In setting a modulus for the magnitude of the broch the internal radius was the obvious choice. It could have been stipulated as a single unit or defined as a multiple of some standard unit of length. If, as we hypothesise, the broch is built to a clear design, it is probable that some standard unit of length, and by extension of area and volume, was used, even if that standard unit was not universal and varied from region to region or from broch to broch. Without some unit of length few of the other bill-of-quantities quanta could be specified and the required resources could not be identified.

Given the ubiquity of the foot as a standard unit, once history is entered, it seems likely that a unit of similar dimension might have been used in the Iron Age.

Unfortunately, there are many and varied foot-lengths in the literature<sup>107</sup> and so, for

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<sup>106</sup> In addition, the use of the arithmetic mean here is probably misguided because all of the likely errors work to reduce the design quantum. Given that many of the external diameters were measured at unknown heights up their inclined plane and above their setting out levels, the relevant distribution is not Normal, but probably a Poisson distribution with 50% as its upper bound.

<sup>107</sup> In their seminal work on weights and measures in Scotland, Connor and Simpson trace the histories and sometimes concurrent use of The Drusian, English glazierø, Scottish glazierø, natural, Rhineland, Roman, Scots and Dumfries foot, in periods in which some standardisation already existed (Connor, R D and A D C Simpson (2004). *Weights and Measures in Scotland a European perspective*.

the following thought-experiment it may initially be imagined that the modern foot was the unit. The mean internal diameter of the measured brochs is 9.45 m, yielding a radius of 4.73 m or 15.518 modern feet. The closest integer multiple in ft is 16 ft, leaving a residuum of 0.482ft (5.8 ins) in 16 ft, or 0.372 ins per foot. Thus, the modern foot might be 3% shorter than the Iron Age foot ( $ft_{IA}$ ).

So much for the theory, in practice, the use of cords would produce errors larger than 3% as a result of their elasticity<sup>108</sup>. The reader will therefore be aware that the pursuit of a standard unit is an exercise in numerology and no claim whatsoever is made here for the realism of the Iron Age foot<sup>109</sup>. MacKie's use of Thom's 'megalithic yard' even speculatively as in his plan of Dun Borodale (MacKie 2007b, 954), is unwarranted because of both the uncertainties in setting out the monument and those of recovering measured data from their damaged remains. These introduce errors larger than any numerical uncertainty in the estimated standard unit. If the builders had a specific measured radius dimension in mind, we are very unlikely ever to be able to recover the units in which it was measured and recovery of the measured modulus, probably the inner radius, measured in whatever units, is unlikely to be possible with any great precision. In addition, if the putative units of measurement varied from site to site, or even regionally, then the standard unit cannot be recovered by statistical analysis of the overall body of avowedly flawed data.

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Edinburgh, National Museums of Scotland and Tuckwell Press.). Euan MacKie has applied Prof Alexander Thom's 'megalithic yard' (Thom, A (1967). *Megalithic sites in Britain*. Oxford, Clarendon Press. And see also Thom, A (1955). "A Statistical Examination of the Megalithic Sites in Britain." *Journal of the Royal Statistical Society. Series A (General)* **118**(3): 275-295.) to some of his analyses of brochs, but this has not won general acceptability, largely it may be suggested because the body of available data is too imprecise.

<sup>108</sup> For example, a leather thong has an index of elasticity of 0.1 and its weight would further reduce precision by the catenary it would form in suspension, even in still air. Taken together the errors could be as large as 6 to 10%.

<sup>109</sup> The rough quarried slabs of the broch offer no simple test of the foot. A careful re-measurement of critical dimensions in the entrance passage, the inner wall thickness and the gallery width all at ground level could be used to explore the matter further but new excavations would be required to provide a viable sample.

This admission of failure seems at odds with the observed precision with which the circularity of the inner wallface can be recovered at ground level and leaves in abeyance the legitimate question ‘how was a broch set out?’ Of course, this is only a problem if it is assumed that the measuring armature was a cord. If instead a wooden armature were used, then at ground level a closely circular trace could be assured. Long riven oak planks were produced in the Iron age and there is no doubt that a cut-down plank or lath could be produced to meet the need even for the longest recorded radii<sup>110</sup>. There are of course some areas in the broch distribution where tall trees might not be available but a suitable coppiced sapling would suffice and could be found almost anywhere. However, a folding version of the armature is well within the competence of Iron Age manufacture and could easily be brought from areas with abundant wood supply. It is implicit to the 2012 paradigm that the materials for building a broch is sourced locally; this is part of an assumed vernacularism of construction. However, there is no *a priori* reason why the broch territory was not interconnected and indeed interconnected with regions beyond the broch distribution, as the presence of exotic imports in the later phases suggests.

It is not asserted that brochs were laid-out using a wooden armature, rather, it is asserted that the use of cordage for laying-out is very unlikely to have given rise to the precision of circularity exhibited in the surviving remains and that a solid armature was required and could have been supplied.

### **Building to levels**

The outer lintel of the guardcells, entrance and of the bolt hole and receiver as well as the base of the outer lintel are often set in the same horizontal plane, and this is identified as a significant building stage, at which the broch masonry is brought to a level, at least locally. One very practical reason for using this building plane in the

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<sup>110</sup> Surviving parts of originally longer oak and alder timbers measuring just under 3 m have been recovered from Scottish Iron Age crannogs (B A Crone, pers comm) and the riven planks from, for example, Black Loch of Merton, were cleaved from oaks over 1.00 m in diameter which would have comfortably supplied the long straight laths required.



**Figure 50 The barhole and slot under construction in a 1:1 model of the Clachtoll broch entrance area. Given the small cross sectional width and height of the barhole and the narrowness of the entrance, failure to insert the bar at this stage would preclude its insertion later.**

entrance is that the bar, a wooden baulk not less than 2 m long<sup>111</sup> and used to lock the door in place has to be inserted at this stage because the geometry of the passage precludes its insertion later (Figure 50)<sup>112</sup>.

Similarly, it has been noted that the scarcement requires construction to a set level around the circuit of the inner wallface. It has been suggested by others (Romankiewicz) that CARs were built in a spiral, which may perhaps be interpreted as a helix. This is improbable for broch towers given the need for level control. In Irish stone forts, notably at Staigue (Figure 51) and Figure 52), significant joins can be seen in the masonry that might encourage the helical interpretation, but no such joints are visible in brochs

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<sup>111</sup> The entrance passage behind the doorjambs is typically 1.2 m wide and the bar receiver hole is 0.3 m deep, so allowing a minimum of 0.5 m still in the bar hole at closure, an overall minimum length of 2 m is indicated. Greater length would allow for the cutting off of a damaged end and bar lengths of closer to 3 m are probably indicated.

<sup>112</sup> It is probable that the instances in which the bar emerges into an irregularly-shaped guardcell are cases in which the entrance masonry has failed and been renewed, see for examples, Gurness and Midhowe RHS guardcells. But note that in these instances the original tectonics of the entrance were being preserved. This was a repair and not an alteration to the broch model. In later alterations the receiver hole was lost.

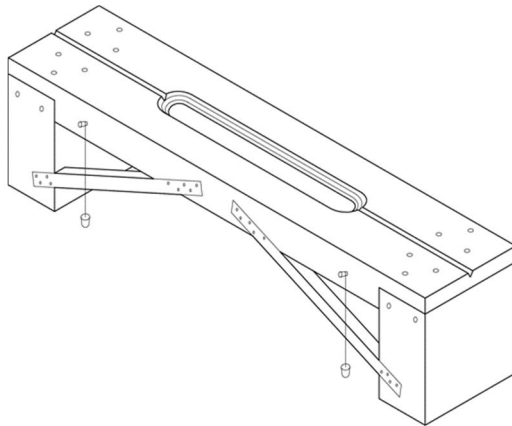


**Figure 51** The Irish stone fort at Staigue, Co. Kerry, comprises a large curtain wall with characteristic X-shaped stairways built into the internal wallface.



**Figure 52 (left)** Staigue's external wallface presents like a brooch tower wallface. However, a clear building break has been observed in the outer wallface that might support an argument for helical building around the circuit of the fort. No comparable building break has been observed on Scottish Brochs.

The observed lintel-tables forming the roof of one gallery and the floor of the one above are, in the vast majority of cases set in the horizontal plane<sup>113</sup> and this implies the bringing to level of these planes, at least within the wall thickness. That said, while the better preserved scarcements are horizontal, there are no other string courses in the exposed wallfaces corresponding to these levelling events. This is merely the consequence of dry stone building with irregular stones.



**Figure 53 Chorobates or levelling table of Roman design. The plumb lines are registered against slots cut into the leg braces and the central well in the table top was filled with water. This version is based on the description in Vitruvius.**

Levelling could be achieved using plumb bobs, essentially simple weights on strings used to establish true verticals. Then a right angle struck from the vertical line would be truly horizontal. In Roman construction, a plum bob was set within a triangular frame with a level base that gives the required horizontality when the hanging string lies centrally to the frame. For longer distance levelling, Roman surveyors and builders used a *chorobates*<sup>114</sup>, a flat table mounted on legs at each end. The surface of the table was made horizontal by the use of plumb lines at each corner. Into the table top, along its median line, a groove was fashioned, into which water was poured, both to check the horizontality of the table and to act as a reflecting surface for someone sighting along the table (Figure 53).

The potential to use the apparent drain around the foot of the inner wall at Midhowe for level control has already been noted (see Midhowe in Chapter 6). Filled with water, plumb bobs with fixed-length lines could be lowered to its surface to establish

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<sup>113</sup> The notable exceptions are Mousa and Dun Carloway, both of which it will be shown later are significantly damaged and deformed and former rebuilt, so these may safely be discounted.

<sup>114</sup> Described by Vitruvius in Book Vii of the *Architecture*.

a horizontal plane around the circuit of the broch at the height then under construction.

Whilst it may seem unreasonable to project this technical knowledge onto Iron Age Scotland, the presence of levelled features within broch towers, of the right-cylindrical, inner wall and of the control of masonry over the circuit of the built walls all demonstrate that levels were controlled during construction. Similarly, while the use of stones of varying thickness means that continuous horizontal courses is limited, the individual stones and groups of stones are truly horizontal, or very nearly so, in the exposed wallfaces. Conversely, where stones diverge from the horizontal it is usually in an area of rebuild, as noted at Thrumster. The suggestion that devices like the chorobates, plumb lines and levels were used have been offered here because their use in prehistoric construction is attested elsewhere and the likelihood is that they, or similar means were available in Iron Age Scotland.

At Dun Beag on Skye and Gurness or Midhowe on Orkney the interior of the wall has been revealed, and conserved. If the impact of overactive conservation can be ruled out, these interiors reveal a core built of horizontally set stones (Figures 114 & 116). In both, runs of 6 to 15 stones of approximately the same thickness can be observed in horizontal groups, which is interpreted as illustrative of the use of loads, possibly cart loads, of stone arriving on site from the same quarried stratum or the same stockpile. Close examination has not revealed helically set groups of this type. It is concluded therefore that the RSM was built up by the horizontal placement of stone, in sequential layers, brought to levels locally, e.g. for entrance features and the insertion of gallery floor/roof lintel tables. The creation of sloping joint planes within broch walls would create the risk of slippage along these planes under the mass of the wall. Similarly, use of rubble infill between wallfaces, the drystone waller's nostrum, would create hazard by its unresolved forces, which acting like an extremely coarse liquid, could force the wallfaces outwards into collapse, a feature unobserved in this study.



## Broch decomposition, natural and anthropic

The second law of thermodynamics ensures that entropy is maximized and order diminished over time in this universe. Thus, even if untouched by humanity, broch structures will decompose over time under the influence of natural forces ranging from climatic to geochemical, all acting under gravity, that will cause disintegration. It is an observation so commonly made as to amount almost to a law in its own right that rates of decomposition typically follow a negative hyperbolic curve (see Leike 2002, for amusing but sound exposition). Rapid initial loss is moderated in time and finally becomes asymptotic with zero or a value close to zero. It is argued here that it was thus with brochs. At first a relatively rapid degradation results from loss of masonry for example, possibly displaced from the wallhead by collapse of a roof, or loosened in a wallface by settlement or the gradual loss of pinnings. Routine maintenance might stall or reverse these losses but neglected, these at first slight imperfections would result in more significant losses. Unchecked, large structural elements would be lost and the base of the structure, inside and out would gradually become subsumed in its own decomposition products. This would slow decomposition and ultimately halt it at some non-zero asymptotic value. Recycling the stone from the monument would again expose original or authentic masonry to loss, and decomposition rates would again rise. Thus, it is clear that the cultural value of a broch, its potential to inform this and future generations (Burra Charter ICOMOS 2013), is a measure of the dynamic equilibrium of a system of competing forces at a point in time. Anthropic interventions have altered the state of the broch at



**Figure 54** The residual broch remains at Bruan, Caithness. The central mound (3 m high) is surrounded by the base of the original broch wall. © RCAHMS

many sites (see Chapters 6 & 7) and created some chimerical monument forms. At Bruan (Figure 54) removal of the good building stone of the broch wall was initially accompanied with dumping detritus into the garth area. Eventually the wallhead was reduced below the level of the dumped material which now stands proud of the vestigial wall foot, and the monument is now shaped rather like a Mexican sombrero. It is highly probable that original and possibly relatively undisturbed archaeological deposits survive within this bizarre monument.

## **The nature of the surviving evidence**

Some 450 of the surviving brochs or probable brochs are grass covered mounds whose scale or history indicate that they cover broch structures. Of the remaining 150 monuments about 70 display some masonry and some structural evidence is recoverable from them. The remaining 80 monuments preserve sufficient structural detail to support their identification as broch towers (indicated by ∅ in MacKie 2007b, xlix-lx).

The 5 best preserved brochs are all in state care and whilst this had many positive benefits, the long history of largely unrecorded modifications is not helpful. The remaining 75 brochs are variously embedded in their own debris fields and reveal only part of the information that would make this study authoritative.

It will become clear that many of the broch towers have fallen down in greater or lesser part and in so doing have distorted the stump of the tower that remains. In addition, the outer wall has a distinct batter. Both of these facts have distorted the basic metrics of the monuments and recorded measurements are problematical. In particular, the external diameter, which is the most commonly cited parameter, is utterly unreliable unless the level above the primary solum at which it is measured can be known and the diameter is measured in the horizontal plane. These and other problems with broch metrics are reviewed later.

Euan MacKie has produced a 3-volume corpus of the brochs of Scotland (MacKie 2002, MacKie 2007a, MacKie 2007b) and Tanja Romankiewicz has commented on many brochs in her recent study also (Romankiewicz 2011). Both authors are

referred to herein and both have made some of the observations on field remains on which this work is founded, but neither has proposed an aetiology for the current forms of the monuments, which this study does, in some detail. Both laudable works have been formed within the paradigm existing in 2012, but this writer has found that approach sterile and sought a more profound understanding of the surviving remains in terms of the creative and destructive mechanisms that brought them to their current states. That this has caused the writer to differ at times from these respected colleagues is perhaps regrettable, but necessitated by the requirement to reduce the power of the current paradigm, which is now poorly founded in the evidence of the broch remains themselves.

The conservation of the cultural value of broch remains is a pressing contemporary need, even amongst those monuments in state care (Properties in Care or PICs) or designated as Scheduled Ancient Monuments. This matter is considered in a Postscript to this study largely because the anatomizing of the surviving remains, both virtually and in fact has provided insights that need to be taken into consideration in future conservation projects. The writer's commitment to two further major conservation projects on the brochs, at Clachtoll and Dun Colbost and at others that are in prospect has lent some urgency to the formalization of current best practice in the conservation of Large Complex Monuments and archaeological engagement with conservation theory and practice.

## Chapter 5 Research questions and methodologies

### Introduction

In the foregoing chapters a series of interconnected propositions has been evolved on the basis of the state of our knowledge of brochs in 2012. These led to the formulation of the RSM and they form the basis of the research questions being addressed in this study. They may for convenience be grouped in three domains, Society, Structure and Settings. Society is such an all-embracing term that its citation is almost meretricious but it is used here principally to identify the source of the primary mnemosac-decision to build a broch tower. The structure itself is a physical object, a denizen of the real world, as herein defined<sup>115</sup>. The settings of the monuments, in combination with physical landforms in which they occur, create landscapes, all of which are conceptual constructs (UNESCO 2013)<sup>116</sup>. Underpinning all three domains, however, are the structure's physical remains, which, being observable with a high probability of repeatability are real world entities as defined for this study, and via their settings are products of the human intellect thus also World 3 entities (Popper 1978a).

The prevailing paradigm assumes that brochs once built, underwent mainly natural degradation with some anthropic destructuring and refitting, all within a tectonic envelope that in essence, remained unchanged. The implicit paradigmatic assumptions, including the LDCU model, about the nature and rates of change undergone by brochs merits critical review. Similarly, the untested paradigmatic assumption that brochs were domestic residences requires some re-examination.

The title of this thesis, 'Approaching the mind of the builder' also subsumes assumptions and those of which the writer is conscious are explored, but of course

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<sup>115</sup> And an entity of Popper's World 3 because it is a product of human intellectual endeavour (Popper, K (1978a). *Three Worlds: The Tanner Lecture on Human Values*, University of Michigan.)

<sup>116</sup> And elements of Popper's World 2, (ibid).

there are generational biases that cannot rise to consciousness and these remain, for future scholars to challenge and test. The concepts implicit in the thesis title are explored through research questions (RQs) which, being too remote from the observable evidence are deconstructed into operational hypotheses (OHs), questions that can be tested and are tested in the negative form of the null hypotheses.

## The Research Questions

### RQ1 Were all broch towers originally built to the RSM form?

*Where:*

- a) *broch tower* means the surviving remains identified as brochs or probable broch towers: initially Mackie's listing
- b) *originally* means the primary build of the monument
- c) *RSM* means the sum of the structural definitions subsumed in Figure 36 and set out in supporting text in Chapter 3
- d) *form* means the shape and proportions of a dry built stone structure disposed to meet its structural challenges in a characteristic manner and contained in the definition of their tectonics

*Study context:* See Chapters 2 & 3

### Operational Null Hypothesis OH1: Brochs were not built to the RSM model.

*Tests:*

- i) Do the remains exhibit the RSM features listed in Chapter 2, Figure 36
- ii) Is the entrance passage ensemble of features evidenced, specifically:
  - a. Are the forces acting on lintels disposed of by relieving structures, viz;
    - i. Stacked voids in the inner wall?
    - ii. Arrangement of lintels and cells in the outer passage?
    - iii. Corbelled cell above the outer entrance behind an outer 'curtain wall'
- iii) Is the inner wall more than 50 mm out of true circularity at ground level?
- iv) Does the placement of the building stones indicate no care to maintain horizontality in the build?
- v) Are the brochs lowest courses on irregular or soft ground but with circular walls?
- vi) Are its proportions indicative of an outer radius twice as long as the inner?

## RQ2 How far has the monument been modified, by natural or anthropic forces over time?

Where:

- i. *monument* means the surviving remains (*sensu* AMAAA 1979)
- ii. *modified* means altered from some known or credibly hypothecated original state
- iii. *natural forces* means forces exerted by gravity, climate or infestation by biota, that jointly or severally altered the state of the monument
- iv. *anthropic forces* means forces deployed by human beings that alter the state of the monument.
- v. *over time* means at any time or over any period between the original build and the 21st century

*Study context: See Chapters 3 & 4*

### Operational Null Hypothesis OH2: Broch remains have not been modified by natural or anthropic forces

*Tests:*

- i) What alterations, of what scale and what frequency can be detected by forensic examination of the remains?
- ii) If alterations are evidenced;
  - a. Are there regional patterns in the nature of the alterations?
  - b. Are there chronological patterns in their occurrence?
- iii) Are the alterations consistent with the LDCU assumption?
- iv) Can alterations be shown to arise from:
  - a. Diversity in original design?
  - b. Idiosyncrasy in build?
  - c. Divergent paths to decomposition?
  - d. Modern intervention?
- v) Allowing for these alterations, can we discern the RSM in the ruinous remains?
- vi) Is the level of observable diversity inconsistent with the Canonicity postulate?

## RQ 3 What constraints did the social context of broch building place on its builders?

Where:

- a) *constraint* means a limitation or restriction

- b) *social context* means the combined physical and social setting in which an observer forms views and makes decisions
- c) *broch building* means both the intellectual processes of decision making and the physical practice of building by placement of stones into conceptually predesigned spaces
- d) *builder* means the commissioning agent, any professional involved, the management and labour involved in the physical build, and the supply-side providers of wood, rope, transport, vittles and accommodation for the project.

*Study context: See Chapter 4*

**Operational Null Hypothesis OH3: Brochs are independent of the social contexts in which they are created, modified and used or reused over time.**

Tests:

- a. Is the social context of vernacular building, implied by the Standard Model, consistent with the recovered data?
  - i. Do we have regional variations of traditional forms?
  - ii. Is the skills requirement demanded by the observed sub-structures and engineering controls too high for vernacular expression and dissemination?
- b. Is the social context of 'professional' construction consistent with the recovered data?
- c. In what way does the existence of the broch (even as ruin) change the social context of its secondary perceptions over time?
- d. Are there spatial or chronological patterns in the secondary and later re-builds and re-uses

**The Operational Null Hypotheses**

In summary

- OH 1. Brochs were not built to the RSM model
- OH 2. Broch remains have not been modified by natural or anthropic forces
- OH 3. Brochs are independent of the social contexts in which they are created, modified and used or reused over time.

The three operational null hypotheses, OH1 to OH3, and their proposed tests are designed to explore the principal aspiration of this study which is to approach the mind of the builder. OH1 addresses the issue of whether the broch is a canonical form of structure or a vernacular structure. The answer to this RQ goes to the issue of the complexity of the mind of the builder, e.g. whether the composite entity

described by the 'mind of the builder' includes a professional class of designers and, or, of vernacular builders only. OH2 explores issues of heterogeneity and the rates and directions of change, over time. It goes to the issue of whether the observable heterogeneity is original or a consequence of divergent paths of change and dissolution, or perhaps both. In OH3 the social contexts of the creation of brochs in the first instance, and of their subsequent social contexts over time are studied. These operational hypotheses form a framework within which the issue of the motivational dispositions of the several commissioners and designers and re-designers of broch towers can be studied and the social, engineering and economic constraints within which they operated can be assessed.

## **Methodologies**

The methodologies deployed in this study fall into three categories, fieldwork methods, post-fieldwork primary analyses, and generic analyses.

### **Fieldwork methodologies: observation and recording**

The first and principal fieldwork method is simply systematic observation of the monuments supported by photographic studies and metrical records. Target areas were selected, Northern Brochs in Shetland and the Orkneys, Caithness and Sutherland; Western Brochs in Skye, the Outer Hebrides and western Sutherland.

Broch towers with the widest range of recorded features known from MacKie's list (MacKie 2007a, xlix ó lx) were prioritised in each area. Each of the selected brochs was visited by the writer with one assistant<sup>117</sup> and roughly half day to two full days were spent on each broch, depending on the volume of recoverable data. Complex brochs like Dun Carloway, Gurness, Clickhimin, the Glenelg group and Midhowe each required several days of study and analysis and more than one visit.

Such observations as could be, were systematised by use of data sheets, which derive from and link directly to the project database, designed by the writer. However,

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<sup>117</sup> Usually my wife or daughter, to both of whom I am truly grateful.



narrative descriptions comprise the bulk of the record. The observations and data recorded in fieldwork were added to the project database which will be archived in the National Monuments Record, in due course.

Examination of each monument began on the approaches to it during which its setting was assessed and the nature of its siting was recorded. The inner wall, complete with its several features, was then recorded and separate data sheets were used to record the intramural features at ground level, and at the accessible upper levels. Then the external wall was observed and measured. The entrance passage was examined, measured and photographed in detail. Finally, lining walls and secondary structures within the broch were noted and recorded.

Photographic recording was widely used and virtually every surface of each monument was recorded. To access high levels for orthogonal photography, the writer modified a window-cleaners telescopic pole and fitted a camera<sup>118</sup> mount to its top, into which a solenoid was built to operate the camera shutter. Almost immediately following the completion of the survey, Canon issued a new camera<sup>119</sup>, the view through its lens being observable, using short range WiFi, in a smartphone, via which the shutter can be operated. *C'est la vie!*

Traditional theodolite survey, measuring polar coordinates was used on Orcadian brochs in which disparate elements of the inner wallface were visible but no measurable diameter could be identified.

Where the masonry of the broch was extensive and visible, laser scan survey was undertaken. Many of the largest surviving monuments were scanned for this study and other scans undertaken by colleagues in AOC Archaeology Group have been accessed also. The laser surveys were undertaken by Dr G Cavers and Ms G Hudson. The brief for the surveys was set out by the writer and the analysis of the results was

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<sup>118</sup> The cameras used were a Canon Power Shot SX220 HS and a Nikon D80 SLR.

<sup>119</sup> The Cannon *Cybershot DSC-WX350*

a collaborative process. The writer specified, and Dr Cavers produced, a form of analysis here termed ‘structural tomography’. This comprises examination of a series of regular cross sections of a broch rising from below ground level to its uppermost parts, which, projected as a video, gives an indication the deformations and distortions that the monument has undergone (see Appendix Tomography). The utility of laser scan surveying is a matter of some debate in the archaeological community (Cavers, Barber *et al.* In Press [2017])<sup>120</sup>. Its great strength is that, programmed to survey within an envelope, the laser scanner does not make any subjective selection of the evidence gathered, but collects all the measurements within the ambit of its raster scan, equally. Traditional forms of survey all entail subjective selection of the points recorded. Of course, any drawing deriving from a laser scan is an interpretation and may, and usually does, involve subsampling of the data; this involves a potentially subjective choice on the part of the researcher. However, the main body of the data is archived<sup>121</sup> and can be interrogated by another observer, to test the writer’s interpretation or to make an alternative subsampling. Traditional survey data does not facilitate critical re-evaluation. Re-survey in the field is the only means of testing an alternative hypothesis arising from a standard survey. For these reasons, laser scanning was relied upon for the best preserved brochs.

‘Evidence’ defined as ‘the available body of facts or information indicating whether a belief or proposition is true or valid’ (OED), in this study, is the subset of observations drawn from all the available observations, which is used to explore or test a proposition. The selection of the evidence is clearly open to paradigmatic bias as indeed is the precedent identification of the explored entity.

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<sup>120</sup> The writer, with Dr G Cavers of AOC and Dr M Ritchie of the Forestry Commission, co-wrote a paper that was accepted following peer review by the Society of Antiquaries of Scotland for the 2017 volume of their proceedings. This is reproduced here at *Appendix Broch survey and analysis*.

<sup>121</sup> Following completion of this thesis, the data collected will be archived with the National Monuments Record of Scotland and made publicly available.

The results of the writer's involvement in excavations at Nybster, Whitegate, Keiss Road, Keiss Harbour<sup>122</sup> and his subsequent direction of excavation and conservation work at Thrumster and Clachtoll have been incorporated into the data set on which this thesis is founded. More extensive reports on Thrumster and Clachtoll<sup>123</sup> are appended to this thesis and are referred to from within the text. The relevant fieldwork methodologies for these exercises are set out in the Standard Operating Procedures of AOC Archaeology Group<sup>124</sup>, a commercial archaeology company owned by the writer.

## Primary analysis of the data

The division between evidence and interpretation is permeable and there is a sense in which evidence itself is an interpretation, resulting from the potentially subjective intellectual processes underpinning its choice. In this study, the term 'evidence' is used to describe isolated, simple, primary observations that have a high probability of being observed and agreed by other independent observers also. Thus, to observe that evidence exists for a panel of stone pinnings at a certain position would usually be undisputed. However, to observe that a group of stones set in a particular configuration is a fragment of a scarcement may be less likely to enjoy universal support, depending on its condition and configuration, and this is more obviously an interpretation than an evidential statement. However, understanding and interpreting the architecture and structural engineering of a broch requires that the existence of such attributes is verified or rejected and for that, the defining criteria of that attribute are required. This process of testing attributes against their anticipated characteristics is here termed 'attribute analysis' while interpreting their status in the light of that test is termed 'attribute interpretation'. The first of the primary levels of analysis therefore subsists in the attribute interpretation of the subassemblies of the broch

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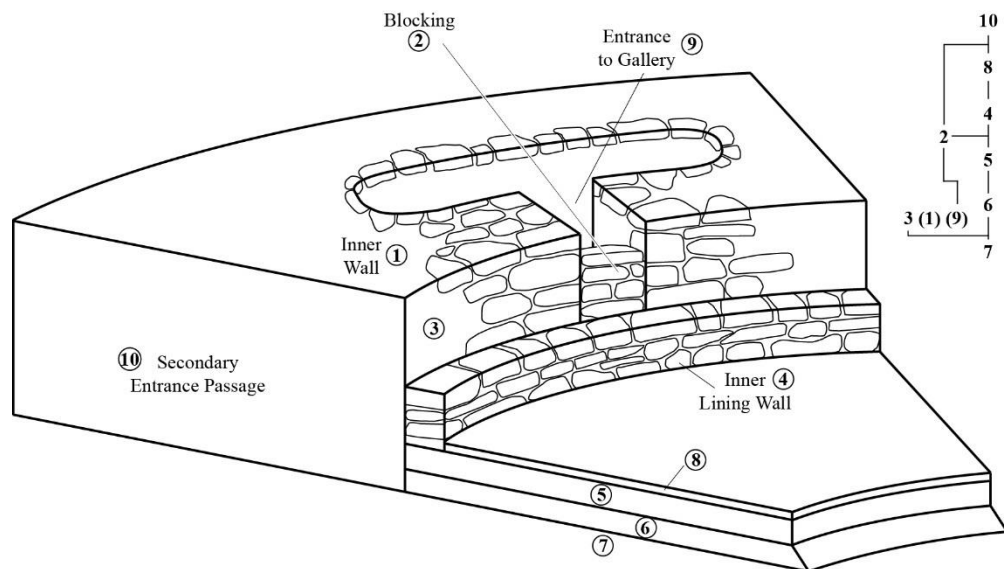
<sup>122</sup> Nybster, Whitegate, Keiss Harbour and Keiss Road were undertaken with my colleagues, Dr A Heald, Dr G Cavers and Dr D Theodossopoulos.

<sup>123</sup> See *Appendix Thrumster* and *Appendix Clachtoll*.

<sup>124</sup> These are approved by the Chartered Institute for Archaeology (CIfA), of which the writer is a Chartered Member and are available from AOC on request.

being examined, following which, the question arising is whether or not each subassembly is typical of the RSM. This requires both attribute analysis and attribute interpretation of the subassembly for its goodness of fit to those anticipated in the RSM model.

Where bodies of masonry can be related sequentially to each other, the possibility emerges for the creation of a Harris Matrix, a visual display of the chronological interrelationships of the attribute-sets of the monument (see Paice 1991 or Buxó, Trócoli *et al.* 1992 for creative uses of the Harris Matrix). For example, Figure 55 displays a simplified matrix for part of the inner lining wall (ILW, [4] in Figure 55) at Thrumster which must necessarily be later than the broch inner wall (IW; [3]) that it lines and the deposits [8] and their contents contained by the ILW must be later still whilst deposits from under the ILW and abutting the IW [5 & 6] date to the interval between the construction of the broch and that of the lining wall (see Appendix Thrumster for further details).



**Figure 55** A schematic drawing of some of the relationships between structural elements and soil deposits at Thrumster. For recording purposes, a feature is the result of a single act of deposition or formation, and each is given a unique number. The Harris ‘matrix’ on the right expresses their minimal stratigraphic relationships which in this case equates with their chronological relationships.

Structures keyed into the lining wall may be contemporary with it or may postdate it, but they are not contemporaneous with the broch wall (see for example Gurness broch, Chapter 6). A blocked entrance passage [9] sealed off by the ILW [4] predates both its blocking [2] and the ILW while the latter is predated by the blocking wall. Not all relationships of juxtaposition can be interpreted. For example, the secondary entrance passage [10] that pierces the lining wall may be contemporary with it, but could postdate it and while radiocarbon dating confirms the latter in this instance it is not demonstrable from the masonry alone<sup>125</sup>.

The observation of evidence for these sequential juxtapositions is part of the primary on-site analysis of the monument and these activities can create a relative chronology of the monument's several parts.

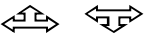
Moreover, as the excavation at Thrumster has shown (Appendix Thrumster) a wall, like the ILW can be diachronic<sup>126</sup> and therefore should not be used uncritically as a single node in a Harris-type matrix. The ILW, (node 4 in Figure 55) can locally be contemporary with the construction of the broch wall but can significantly post-date its construction in adjacent areas. Part of the ILW is set on subsoil in the T2 trench but it overlies deposits formed within the broch and seals off the entrance to the ground floor gallery within the wall, only 3 m away. Alterations in the masonry must represent this diachrony but the difficulty arises not from an absence of observable breaks demonstrating alteration in the masonry but from a great superfluity of them (see Illus 33 in Appendix Thrumster).

Subdividing wall faces on the basis of observed changes in masonry is highly challenging and whilst it is often tempting to try, this temptation should perhaps be

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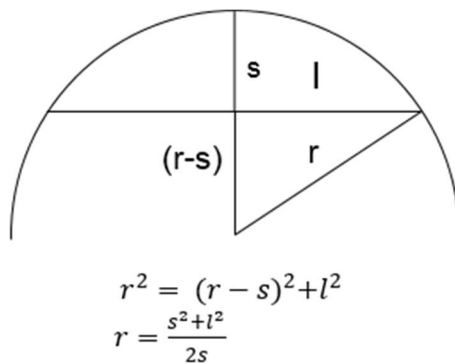
<sup>125</sup> Once the matter was resolved by radiocarbon dating, it was easy to see masonry breaks that confirm the secondary nature and relative dating of the entrance.

<sup>126</sup> An archaeological borrowing from linguistics, diachronic means here a deposit or structure that has developed or been formed over time, either gradually or intermittently.

resisted. Usually building joins between stones meeting at nodes in a wallface face offer three paths, left and right and up or down: 

If a path being selected approaches a node, say from the right, there are two choices of how to proceed beyond it; move left or move up or alternatively move left or down. In passing just 20 nodes, over 1 million different choices can be made. Thus, any strongly preferred interpretation can find an expression in the masonry by the unconscious bias in the observer's selection of pathways through it.

Where the primary survey indicates that the inner wallface was not orthogonally circular, an application of the *Sagitta* construction was deployed to measure the radii of curvature around the wallface (Figure 56). This was helpful in cases in which the curve of the inner wallface comprised multiple arcs of varying curvature, as for example at Carn Liath (Appendix 6.1) where their proliferation points to rebuild episodes of the wallface that that may not otherwise be evident.



**Figure 56** The sagitta (s) can be used to find the radius and centre of a curvilinear wall, using the formula shown here. However, its estimates of the radius are very sensitive to small changes in 's', reducing its utility in field conditions.

## Building Chronologies

### Taphonomy

Relative chronologies are so called because they establish sequential relationships between features or deposits on an archaeological site or monument but do not establish calendrical dates for them. The general law of superimposition suggests that if Deposit A overlies Deposit B, then A is later than B. Its simplicity makes this rule dangerous because, and repeatedly on deeply stratified sites, early deposits may have been dug into from a higher level, onto whose solum materials from the deeper deposit/s are then redeposited, asynchronously. On soft sediments traffic can churn the upper layers constantly, as the deposit deepens, blurring chronological

boundaries and reducing chronological resolution. As already noted, a ILW inside a broch abuts the IW and must be later than it, albeit that it could simply be later by the duration of a construction phase measured in days, or it could be centuries later, the latter being the case in some areas at Thrumster (Appendix Thrumster). Relative chronologies rarely give direct evidence of the scale of the chronological durations of events because time is lost in the boundaries.

Taphonomy is the study of deposit formation, and deposit here means any anthropic assemblage of materials from soil dumps to structures. Unless the taphonomy of a dated deposit is understood, the date from that deposit is quite likely to be misleading. With broch-related chronologies (see for examples Gilmour 2005, especially his tables 1 to 7) the vast bulk of dates are derived from materials found on, in or around the broch monument and thus do not date its construction, as Dockrill *et al* have demonstrated (Dockrill, Outram *et al.* 2006). Among the reasons for the paucity of construction dates is that the built monument, which in brochs is the wall structure, is rarely excavated and even when it is, the excavator has to have the good fortune to find suitable samples<sup>127</sup>.

Carver, on the dating of structures or deposits from coins found in them is at pains to emphasise the risks of equating dates from contents with dates for the container. He suggests that coins:

are at least very rarely contemporary. In spite of this, equating the date of a building with the date of the coins found in it remains a widespread practice. (Carver 2015, 79)

Dating the container by its contents is clearly a high risk strategy, but this problem is common to all structural remains and, for example, plagues the study of Neolithic burials in chambered megalithic tombs where although up to 1500 to 2000 years may

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<sup>127</sup> The presence of the sheep leg and foot in the primary build of Old Scatness (*ibid*) or carbonised barley seed samples below and above the floor slabs of the gallery or the infill of a pre-broch gully at Thrumster (Barber, in Appendix Thrumster) were matters simply of good fortune; their presence could not have been anticipated. But perhaps like darts players archaeologists get luckier the more they practice.

separate the earliest from the latest burials deposited in the monument (see Barber 1988, 60) some authorities, like Hedges, have treated the deposition of human bone as culturally coherent and indicative of a single Neolithic rite (Hedges 1982) whilst other writers found on dates guessed at from the earliest dated burial (see for a particularly lucidly argued example, Sharples 1981, 54-9). Henshall, the doyenne of Scottish Neolithic tomb studies emphasised the importance of circumspection in dealing with chamber floor deposits:

-It follows that many conclusions based on this deeply unsatisfactory material should be abandoned, or at very least re-examined (Henshall 2004, 88)

Regrettably, there is no corresponding scholarly quotation to cite in respect of the contents of brochs and their use in dating the structures.

### **Radiocarbon chronologies and calibration**

Radiocarbon dating relies on the fact that the ratio of  $^{14}\text{C}$  to  $^{12}\text{C}$  carbon isotopes in organic matter is relatively stable, which it is, but it is not a constant and can vary significantly over timescales as short as a century<sup>128</sup>. Dendrochronologically dated tree rings, precise to one year, have been radiocarbon dated at 10 year intervals (Renfrew and Bahn 2012, 138) to provide a calibration curve (Bronk Ramsey 1995) that purports to calibrate radiocarbon determinations as calendar dates. Calibration, strongly influenced by the local shape of the curve, can return proxy-calendrical ranges of several centuries<sup>129</sup>.

Various statistical processes have been used to try to improve on the very low precision of the calibration process, of which Bayesian Analysis is the current vogue (see Bayliss, van der Plicht *et al.* 2011 for many examples). Bayesian methods can expand the basis of the analysis to include other information from the excavation,

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<sup>128</sup> Radiocarbon determinations are reported as means and standard deviations, the latter now usually of the order of  $\pm 25$  years.

<sup>129</sup> Thus, the primary occupation at Bu, an Early Iron Age house, returned a radiocarbon determination of  $2470 \pm 95$  bp (or 520 bc  $\pm 95$ ) which calibrates to 830x385 calBC.



such as the relative stratigraphical relationships of the dated samples or beliefs and assumptions from other comparable monuments. While the outputs of Bayesian analyses of groups of dates somewhat reduces the imprecision of the calibrations, their results for Iron Age Scottish sites remain too imprecise to contribute to answering questions based on even generational time-spans. Also as noted above, the imprecision of the methods of dating and analysis, are amplified by the unfortunate fact that the brochs lie in or close to the Hallstatt Plateau and its adjacent artefacts of calibration (see Reimer, Baillie et al. 2004, Bronk Ramsey 2005 or Dockrill, Outram et al. 2006, 98 for details). This severely degrades the precision of the calibrated dates in or near the 800 to 400 BC range.

No statistical test proves a hypothesis; it merely assesses the goodness of fit of the hypothesis under test to the available data. Thus, while Bayesian statistical tests of the radiocarbon date framework of Thrumster does not contradict the standard model reading of the evidence (see the SM2012 compliant Hamilton model in Appendix Thrumster) neither does it contradict the counter paradigmatic interpretation of this writer (ibid the Barber model). Interestingly, its outcomes directly parallel those from Old Scatness (Dockrill, Outram et al. 2006) and together both point to a construction date for these brochs at or before 300 BC and possibly as early as 400 BC. This is assumed here to be the construction date of these RSM brochs and to categorise the period in which such brochs in general were built.

The fine detail of the RSM's chronological histories can only be clarified by repeated observation of the chronological relationships involved across several well excavated brochs. This may reveal that patterning exists in the dates of primary construction, and perhaps also in significant episodes of subsequent redesign or re-build of the primary broch. If elements of that patterning exists in earlier site reports containing competent radiocarbon dates, these could also be used to establish an outline calendrical framework for the observed patterns of use and reuse.

## **Intervisibility**

Fojut has explored the potential intervisibility of brochs in Shetland in response to the widely held belief that all brochs are intervisible with their other brochs (Fojut

2005b, 147). It should be noted that areas mapped as zones of theoretical intervisibility (ZTVs) in GIS software do not demonstrate intervisibility of the monuments or loci indicated. The available digital terrain models (DTMs) from the Ordnance Survey, are positionally imprecise to something like  $\pm 20$  m and the contour-generating algorithm is rather coarse, so that it is possible that isolated ridges, rocky outcrops or local knolls may intervene along sight lines identified by the GIS package as lines of intervisibility.

In addition, of course, the OS maps are bare-earth maps and no cognisance is taken of vegetation or structures that may also interrupt lines of visibility. Our knowledge of the structure of Iron Age tree cover in the north of Scotland is slight but what exists suggests that some tree cover survived in most areas and may have been extensive in some. Other than by undertaking specific pollen analyses close to monuments, it is not possible to estimate the extent to which brochs could have been



**Figure 57** The Sardinian nuraghe of Sta Christina at Paulolatio (above left) survives to half its original height and is quite fully masked by the surrounding olive trees. Even at full height it was never easily discernible. On the right, a nuraghe indicated by the arrow lies hidden in trees, barely discernible from the wallhead of the example from which this image was taken.

hidden in the shrubbery. The Sardinian Nuraghi are 10 times more numerous than

brochs and are twice as tall as them and yet, it is often, but certainly not always, difficult to see the nearest neighbouring monument even from the summit of a Nuraghe because of tree cover (Figure 57). The net effect of all of these factors is to indicate that a ZTV is an over-optimistic statement of potential intervisibility.

Some consideration is also given to exploring the access to the broch for stone and other deliveries and to looking at the possible stone quarries in the vicinity, which is set here, arbitrarily, at likely to exist within about 500 m of the monument. In a later chapter the use of carts for hauling stone to the building site is explored. In this context, the fact that the causeways to brochs in lochs in the Western Isles like Dun Sticer (MacKie 2007b, 1159) or Dun Torcuill (ibid, 1160) or indeed Clickhimin in Shetland average more than 1.5 m wide is of some interest. This is far wider than would be required for access on foot and may go to the issue of routine transportation for stone and other materials by cart which is discussed in Chapter 8 (Transport of stone).

## **Field work programme**

The broch distribution was divided into 5 areas on the pragmatic basis of travel arrangements, and one to two weeks were spent in each area. These comprise i) Shetland, ii) Orkney, iii) North East Mainland, iv) West Coast, and v) Western Isles. Where possible up to 5 priority monuments would be visited in each area and as many minor examples as time allowed. In addition, the normal workload of AOC Archaeology Group routinely cast up broch surveys and other broch related studies and advantage was taken of this commercial work programme to see and be involved in the survey and recording of additional brochs and broch-like structures. The monuments visited and recorded are listed in Table 2.1, on which those laser-scanned are also indicated. Some of these surveys are perfunctory either because of the condition of the monument in question or because the survey was undertaken to address a narrower remit than that which this study requires.

## Chapter 6 Case Studies Part 1; northern and eastern

### Introduction

The major brochs, in which most attributes can be seen, are presented in this chapter and in Chapter 7 as case studies in which the SM2012 configuration is queried and the RSM is tested. Some mid-range studies have been set out in Appendix 6.1; these are brochs that have more than average observable features but not as many as in the main case studies. Finally, the other broch remains identified by MacKie as tall structures, but excluding non-circular remains and semi-brochs, their attributes now existing and those for which reliable historical records exist have been tabulated in and are presented and discussed in Chapter 7 (Tables 7.3a to e). This is a structured sample but random only in the respect that the early excavations which revealed the greatest amount of detail were not selected by any systematic process.

Chapter 6 discusses Mousa, Clickhimin, Midhowe, Gurness and Thrumster from the perspective of their deviations from the RSM form. In essence, if those features that deviate from the projected RSM norms of structure, form and tectonics can be shown either not to be deviant or to be variations imposed on an originally canonical form, then the argument that brochs were a canonical build will not have been refuted by the evidence.

Those monuments in which the evidence is most clearly visible are also those that have been extensively excavated and studied since the nineteenth century.

Unhappily, ill-informed reconstructive conservation has taken place on most of them and sometimes its scope is unrecorded. Continuing maintenance works, similarly unrecorded, progressively mask and occlude key features. These observations are not new, and Euan MacKie's corpus contains several relevant comments, for example on Carn Liath, where, *inter al*, he comments on the loss of the bar hole in the entrance passage since 1909 (MacKie 2007a, 638); he comments further on several other monuments throughout the corpus q.v. (MacKie 2002, MacKie 2007a, MacKie 2007b). Brian Smith (Smith Forthcoming) has prepared a very fine exegesis of the monument at Clickhimin, Shetland in which he details the confusion of ancient and

modern work on the monument and he argues that the latter has misled MacKie in his interpretation of this key monument.

John Hedges has noted that at the excavations at Gurness (1930 to 1939):

-There was from the beginning a constant bias in excavation towards structures, stripped of unnecessary adhesions, which could be consolidated and displayed. This was because, whether the Society of Antiquaries [of Scotland] or HMoW were the organising body, display was one of the primary and explicit objectives of the exercise.ø(Hedges 1987, PAGE REF)

The -unnecessary adhesionsøwere in the main, alterations to the broch structure and probably mostly Iron Age in date. Alexandros Veloudis studied modern interventions in Clickhimin, Mousa, Gurness, Midhowe and Carn Liath, in his Masters Dissertation at ESALA, University of Edinburgh. He notes about these monuments that;

-Some of them have clearly had restoration work done and that is evident today, while others project a much more complicated image that is almost unreadable. In some cases any modifications are unrecorded either because it was considered unnecessary at the time, or due to unprofessionalism.ø(Veloudis 2013-14)

The Athens Charter was adopted at the First International Congress of Architects and Technicians of Historic Monuments, Athens 1931<sup>130</sup>, and the concepts associated with scientific restoration (Boitoø -*Restauro Scientifico*ø Boito 1893) may not have been unknown to the architects preparing these monuments for presentation. However, in Britain, the tension between the *stylistic reconstruction* of the early 18<sup>th</sup> century (championed by Eugene Viollet-le-Duc) and the strict conservation ethos championed by John Ruskin and the Society of the Preservation of Ancient Buildings (SPAB) in Britain had not converged on the principles of *scientific restoration* of the

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<sup>130</sup> <http://www.icomos.org/en/charters-and-texts/179-articles-en-francais/ressources/charters-and-standards/167-the-athens-charter-for-the-restoration-of-historic-monuments>

early 20<sup>th</sup> century but remained and remains largely unresolved (Glendinning 2013<sup>131</sup>), certainly as far as the conservation of brochs is concerned. Consolidation, with remodelling was undertaken at Gurness each year after the archaeologists had left the site (see Hedges 1987 Part II, 2). There is an illuminating contrast between Hedges description of the working practice at Gurness (cited above), and the recommendation in Article VI of the Athens Charter that:

-It should be unnecessary to mention that the technical work undertaken in connection with the excavation and preservation of ancient monuments calls for close collaboration between the archaeologist and the architect.ø  
(ICOMOS 1931)

It will be clear that the white heat of European discussions on monumental conservation was little felt in Orkney between 1930 and 1939, and it is to be feared that this situation may not yet be wholly remediated for prehistoric structures in Scotland.

Thus, in reading these monuments, it was always necessary to be aware of the potential for misleading interpretations based on unrecorded modern interventions.

The canonicity of the RSM and its engineering design also contributed to the formation of patterns in its decomposition. The tendency for brochs to decompose at their entrances has already been noted and one secondary consequence of this has been the use of the stair foot cell to form a new entrance<sup>132</sup>. In the SM2012, these patterns of decomposition and secondary alteration have been confused with original design features and this has been remedied in site observation, in so far as that is possible without physical interventions in the fabric. Reliance has been placed on the

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<sup>131</sup> For a useful and stimulating account of conservation in the 17<sup>th</sup> and 18<sup>th</sup> centuries, see the Introduction and Chapter 2 of Glendinning, M (2013). *The conservation movement : a history of architectural preservation : antiquity to modernity*. Abingdon, Oxon, Routledge.

<sup>132</sup> Entrances at Ness, Keiss Harbour and Yarrows brochs are secondary and so probably are those at Brounaban and Keiss Road and both of the Clickhimin entrances. A stair foot entrance at Freswick Links, also believed to be secondary is now lost. In excavation, Thrumster and Old Scatness have recently revealed secondary stairfoot entrances.

writer's experience in modelling dry stone structures and in the lessons learned under Dr Theodosopoulos's Masters programme in testing scale models of brochs and broch walls.

## **Mousa broch**

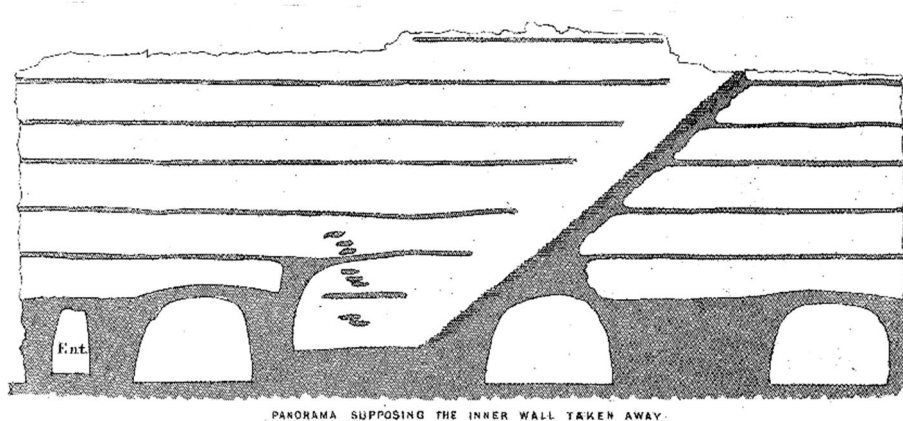
The broch of Mousa stands almost 13 m high and it is the iconic broch. Fojut's perceptive conclusion that 'Mousa is a broch but no other broch is a Mousa' (Fojut 1981) needs to be borne in mind because while Mousa is iconic it is also atypical.

Mousa's bibliography is extensive if not always illuminating and the following, whilst not exhaustive, is a reading list of the most relevant sources for this study. Dryden surveyed Mousa in 1852, but was not able to survey its lower levels until the interior had been cleared out by Mr J Bruce of Sumburgh, without record. Dryden completed his survey in 1861 (Dryden 1890). In 1922, Paterson published a survey of the monument undertaken in 1919 by the Office of Works during repair work and this corrects and extends Dryden's survey in some details (Paterson 1922). Anderson commented on the monument in 1883, in his Rhind Lectures (Anderson 1883, 174-180) and initiated the scholarly study of the monument that continues to this day (Finnie 1990, 45-6; Armit 1998, 98; Gilmour 2000, Henderson 2000; MacKie 2000, MacKie 2002, 82-87; Armit 2003, 13-15 and passim; Armit and Ralston 2003a, 184; Armit and Ralston 2003b, 47-8). Inventories, Site Guides and Guidebooks also describe it in varying degrees of detail (RCAHMS 1946, 48-55, No 1206; Cruden 1951; Feachem 1963, MacKie 1975, 271-4; Ritchie 1985, Ritchie 1997; and Paxton and Shipway 2007).

## **Stairway**

By the start of the 20th century, and based on the surveys of Dryden and Paterson, the identification of the essential characteristics of all other brochs were founded on those observed at Mousa. Figure 58 shows one of Dryden's sections through the monument in which ground floor cells and upper floor galleries are indicated, together with the helical stairway that leads, unbroken, from the second level to the wallhead. This arrangement isolates the galleries to which access can be gained only

by leaping back across the stair hole to the nearest lintel of the gallery floor, some 3 to 4 m distant (Figure 59 and Figure 59)<sup>133</sup>.



**Figure 58** Dryden's sketch of a circumferential section through the plane of the galleries, revealing the helical stairway.

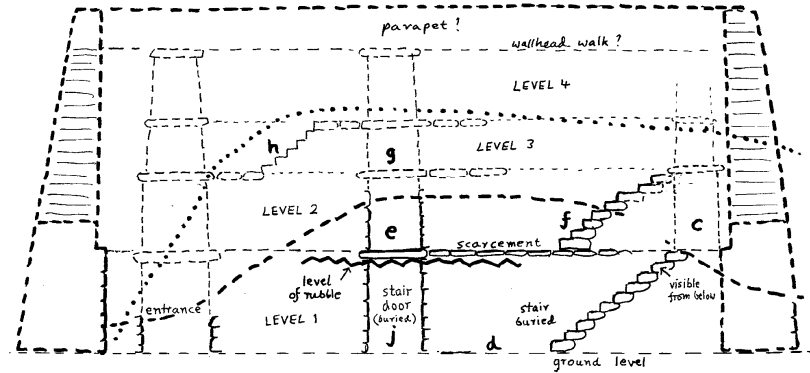
No evidence survives in the masonry for a wooden structure that could have facilitated access and if one had been continuously used, some indication of that use is likely to have survived.



**Figure 59 (left)** View down the helical stairway, revealing two gallery floors. Note the several adjustments to the curvature and location of the left hand wall, i.e. the wall abutting the interior of the broch. This wallface has been stepped back from the stairwell in three stages and follows a recurved footprint in the uppermost. It is probable that this is associated with the secondary insertion of the helical stairs.

<sup>133</sup> Further sketches and survey drawings by Dryden can be consulted in the Canmore database, (<https://canmore.org.uk/site/944/mousa-broch-of-mousa>) from which the image shown here is derived under Creative Commons.





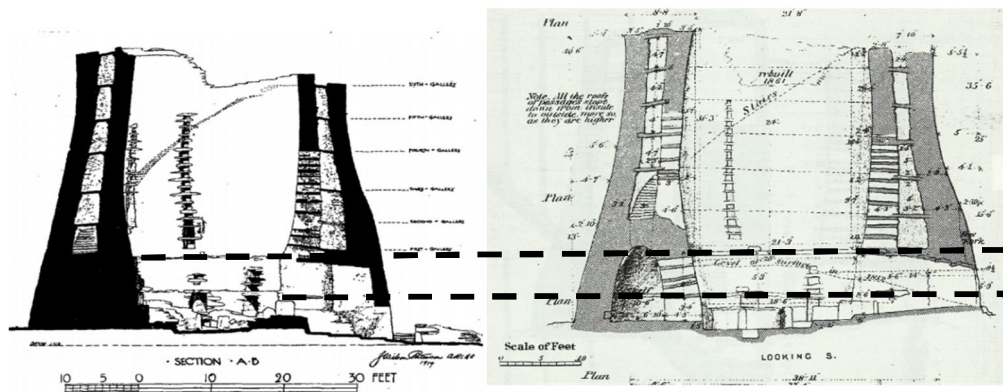
**Figure 60** Euan MacKie's drawn interpretation of the evidence from Dun Bharabhat, based on Captain Thomas' 1861 survey (after MacKie 2007, 1182)

The helical stairway at Mousa (see Figure 58 from Dryden's survey) is inconsistent with the tectonic system evidenced at all other brochs which comprise interrupted flights of stairs accessing the second and third level galleries albeit that no unambiguous example has been preserved. However, MacKie, in 1989, observed what he believed was the lowest stone of a second flight of steps, originally discerned by Curle in c. 1920, some 5.7 m clockwise of the extant stairhead at Dun Telve, and note the vestigial and damaged remains of a cognate layout at Dun Carloway (Chapter 7). The scheme drawn by MacKie for the site at Dun Bharabhat, based on the 1861 survey by Captain Thomas (MacKie 2007b, 1182; Thomas 1890, Plate XLVIII) comes close to what is proposed above in Figure 60. The Bharabhat drawing is closer to the norm for broch stairways than Mousa can be.

### **The entrance passage**

The entrance passage to Mousa has undergone considerable change from its original build and change continued between the 1861 survey by Dryden and the 1919 survey by Paterson. These are illustrated in Figure 61 in which the upper horizontal broken-line represents the level of the mid-height scarcement and the lower line the level of the original entrance lintels. The ground level in the entrance passage now rises toward the interior, as recorded by Paterson. That recorded by Dryden drops toward the interior and it is clear from this that despite the removal of the infilling deposits before Dryden's survey, significant deposits still remained *in situ* in the entrance

passage in the late 1800s. The door ope had been heightened by slapping out the outer wallface, probably in antiquity, to allow continuing access above the raised



**Figure 61** Surveys by Dryden, 1861 (right) and Paterson, 1919, (left) revealing alterations in the entrance area and further and unrecorded removal of deposits thence and from the broch interior in the intervening years. Note also Dryden's record of the floor level in 1852

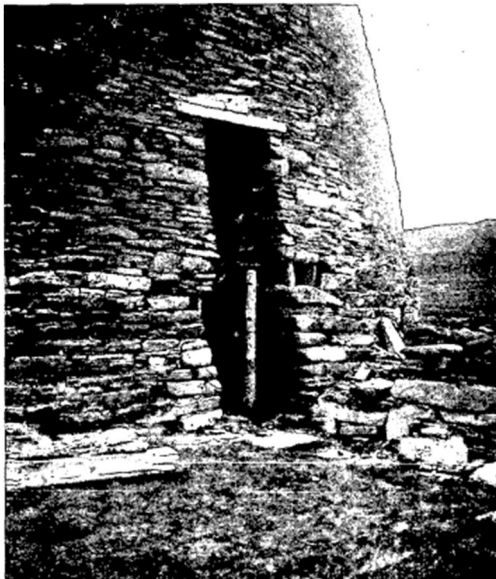
The entrance passage to Mousa has undergone considerable change from its original build and change continued between the 1861 survey by Dryden and the 1919 survey by Paterson. These are illustrated in Figure 61 in which the upper horizontal broken-line represents the level of the mid-height scarpment and the lower line the level of the original entrance lintels. The ground level in the entrance passage now rises toward the interior, as recorded by Paterson. That recorded by Dryden drops toward the interior and it is clear from this that despite the removal of the infilling deposits before Dryden's survey, significant deposits still remained *in situ* in the entrance passage in the late 1800s. The door ope had been heightened by slapping out the outer wallface, probably in antiquity, to allow continuing access above the raised floor level. The passage lintels had also been slapped out, leaving the tuskings that remains today. The outermost modern lintel is about 0.5 m below the level of the surviving stumps (represented by the lower broken line in Figure 61) while the top of the entrance ope in Dryden's surveys lies about 1.2 m above the lintel stumps.

It must be concluded that the interior of the broch had become infilled with debris into which structures were also built and it may be concluded also that the outer ground level had similarly risen with debris and probably slight structures.

Continuing access was first ensured by slapping out the passage lintels, and using the

same entrance doorway, entering up a steep ramp into the higher level interior. The lower scarcement is damaged and disturbed, probably as a result of the collapse of material into the broch. With the upwards migration of the floor levels a new scarcement was inserted at the mid-level which has since been identified as an original feature of the broch.

It is not possible now to be certain but it is possible that this was the condition in which the Vikings found the monument.



**Figure 62 (left) The entrance to Mousa being reconstructed in about 1919, prior to Paterson's survey. The original (1922) caption reads 'Original Entrance with later Doorway above' Paterson 1922 his Figure 5. 178).**

As noted, the original ingress was completely sealed off with infilling deposits and a new opening was forced through, at and above the level of the original lintels (Figure 62). Finally, a new entrance was made, the interior emptied and the high-level

breach infilled during the 1919 works that occasioned Paterson's survey. These works included the use of concrete within the passage to support a newly built infilling of the breach above the original entrance in the outer wallface and the insertion of the modern door lintel. The current vertical form of the entrance passage is a modern fiction.

MacKie, ever the acute observer, has noted most of these matters and argues that the enlargement of the entrance is an ancient modification to an entrance passage that was until then, a perfectly standard broch entrance (MacKie 2002, 8-9); a conclusion with which this writer agrees. The tussling of the slapped-out lintels of the original passage can still be identified as can the locus of the corbelled cell above the outer end of the passage (ibid). Therefore, and despite its currently anomalous appearance,

it is clear from the observable evidence that the entrance to Mousa was originally built in the form indicated in the RSM.

### The outer wallface

The high breach above the original door ope is illustrated in Paterson's paper, in a photograph of the entrance (Paterson 1922; 178: Figure 62 above). The wallface masonry above the current entrance is clearly built in a different plane from that of the adjacent masonry with relatively clear differences in the masonry build (Figure 63). This is similar to the wallface configuration above the entrance at Dun Telve,



albeit that the latter lacks the early photographic evidence available for Mousa.

**Figure 63 (left) The outer wallface above the current entrance at Mousa. The edges of the inserted masonry are indicated by a proliferation of small slabs and an extensive rispains joint on the right.**

**Figure 64 (right) Profile on the north east of the monument is steeply battered and linear in section to about mid-height above which it becomes vertical, in two stages.**



The profile of the outer wallface is highly variable around the circuit of the broch (Figure 65). A generic view of this variation has been fastened upon as a normative feature of broch towers which are thus represented in the SM2012 (Figure 26). Under field observation, these variations in profile seem likely to have resulted from damage to the wall, combined with the effects of losses



**Figure 65 Outer Wall profiles at Mousa. The LHS image probably best preserves the original battered profile of the broch wall in its lower half. The various bulges and out-thrusts, in places beneath slightly overhanging upper part is most probably Viking in date. (These images are only approximately correctly aligned for height relative to each other).**

from the wallhead, on the one hand and rebuilding on the other. In Figure 64 The linear wall slope of the lower half of the wallface on the NE side is probably close to the original profile of the monument, some 11.58 degrees (this is the left-most image in the composite in Figure 65).

### **The inner wallface**

It will become clear below from the current state and the earliest records of the brochs at Dun Telve and Dun Trodden, that the stacked voids extended to the wallhead and this is the normal expectation. The three long stacked voids at Mousa terminate at different heights, the difference between the highest and lowest being about 1.8 m (i.e. about 6 ft as scaled from Paterson 1922, 176, his Figure 4). Their unequal heights would be explained if the upper wall had collapsed; an event also indicated by the infilling of the interior, noted above. The rebuild would then have encapsulated the voids at the uneven heights of the fracture surface. The highly fragmented lower scarcement could have been damaged in this collapse.

Taken in the round, the outer wallface gives evidence of localised distortion from a simple consistent batter in its lower half that represents the original linear broch profile (see left hand image in Figure 65). Above an average level of 4 m beneath the wallhead, the masonry is near vertical and in places slightly overhanging and seems best identified as a new build atop an extant form. The merging of the masonry is well managed.

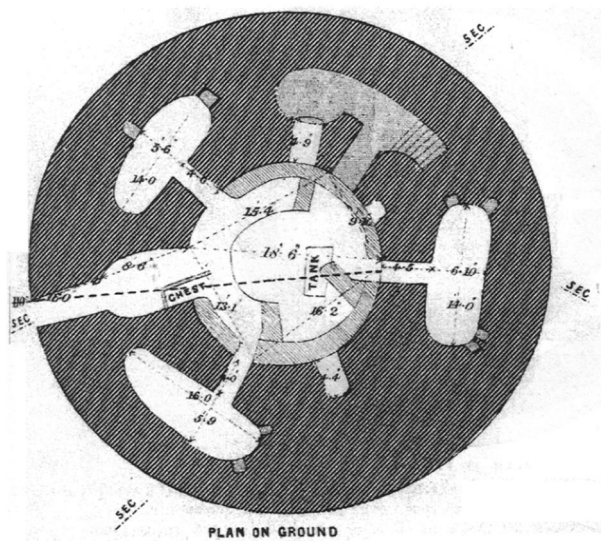


**Figure 66** The internal wall foot at Mousa. The broch entrance appears at both ends of this panorama. Short stacked voids are positioned over the entrance lintels of the wall cells and some aumbries. The wall between the entrance, on the left in this image, and the stair access ‘S’ seems extensively rebuilt.

Several significant cracks exist on the outer wall, especially in the quadrant right of the entrance, but nothing in the outer wall indicates the levels of strain visible in the inner wall. It is possible that the whole of the outer wall was reskinned to take the wider upper works needed to force a helical stairway to the wallhead. The RSM model envisages a convergence of the battered outer wall with the vertical inner wall. If the wall were required to contain a stairway to the wallhead and the wallhead were to be expanded to take a wall-walk and breastwork, some down-taking of the broch would have been required, unless it was already in partially collapsed as the evidence suggests. Then an upper segment of near vertical wall could be built up to meet the new requirements. The fact that the outer wall's lower battered profile merges with the putative upper rebuild at varying heights and in varying profiles, further suggests that the wallhead had been unevenly reduced by the earlier collapse episode hypothesised above and the new build starts at variable height creating variable outer profiles. The ground level inner wallface is partly obscured by secondary benches of masonry whose function remains obscure but is related to the secondary structures built within the broch (See Levenwick broch in Appendix 6 for comparandum). The masonry benches may have functioned as a path around a wheelhouse, or its equivalent, also giving access to the stairway. MacKie notes that the benches were

thought to have had opes in line with the entrances to the wall cells but this is no longer obvious in all cases. Three main cells are accessed from the garth via the 1st, 5<sup>th</sup> and 7<sup>th</sup> opes, indicated by arrows on the panorama, Figure 66.

The 2<sup>nd</sup>, 4<sup>th</sup>, and 6<sup>th</sup> opes access short passages that are described as aumbries. However, they are rather long to serve only as cupboards and they may be relict features from an earlier arrangement of the intramural cells. The 3<sup>rd</sup> ope (marked -SØ in Figure 66) set above ground level, is the access to the stairway via the lowest of its stacked voids. There is abundant evidence here of the conscious management of dead weight loadings on lintels.



**Figure 67 (left) The ground level plan of Mousa, from Dryden's survey. Measurements are cited on the drawing in feet and inches**

Dryden's measurements of the opes into the inner wall at ground floor level include measurements of the lengths of the cell entrance passages and the aumbry depths. In



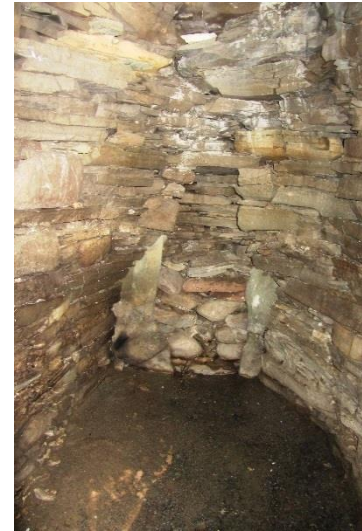
general, these measurements should approximate to the thickness of the inner wall, which averages 0.93 m (3 ft) for all brochs. At Mousa these measurements average 1.3 m. Far from conclusive taken alone, these measurements nonetheless indicate the possible existence of an inner lining wall that possibly reaches to

**Figure 68 (left) The entrance to cell B, with a possible building break shown in the masonry to one side indicated by the arrow. The absence of building breaks in the other cell entrance passages renders this moot.**

the wallhead, or at least to one or other of the scarcements, above each of which the wallface is inset. A clear building break can be observed in the entrance to Cell B (Figure 68), but not in the other cell entrances.

A total of 8 aumbries can be found in the three cells, and in Cells A and B, vertically set slabs are inset into the wallfaces at cell ends (Figure 67). Finally, one end of Cell C, contains what appears to be a blocked entrance possibly to a gallery (Figure 69).

Aumbries are diminishingly rare in broch architecture and, with inset stone slabs, tend to be associated with later structures in and around the brochs. It is suggested therefore that these cells were remodeled in some secondary Iron Age phase of reuse possibly associated with the insertion of the internal structures, and incorporated features that had become common on structures of the first or second centuries BC to AD.



**Figure 69** A possible blocked passage in the end wall of Cell C, Mousa.

The blocked entrance in Cell C simply emphasizes the scale of the changes within the wall thickness.

Excavations at Thrumster (below) revealed major changes to the intramural features over time and recent

investigations at Dunbeath showed the insertion of a rectilinear wall chamber significantly higher than the original broch solum (Appendix Dunbeath). Similarly, guardcells at Midhowe and Gurness have been substantially rebuilt so the idea of remodeling features within the wall thickness need not occasion surprise.

### **The Stacked Voids**

The inner wallface of the broch at Mousa bears three long stacked voids, one rising above the broch entrance, one associated with the stairway entrance and a third that probably rose from a doorway above the scarcement (on right in Figure 71). The latter is set above, but offset from the line of one of the aumbries and it is unlikely to have been intended as a relief mechanism for the aumbry. If, however, the aumbry is a relict entrance to a now lost gallery or wall-cell, the presence of this relieving structure would be explained; it is a relict feature from an earlier configuration. This

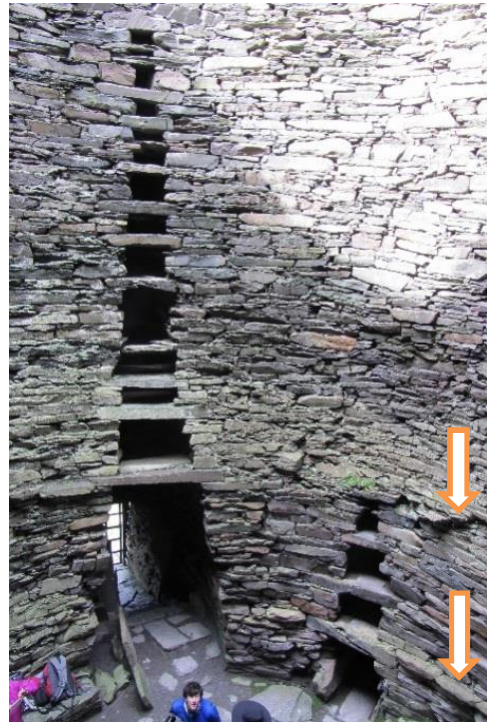


implies that their retention was not antithetical to the tectonics of the secondary and later re-users of the structure. Of course, removing a stacked void would have been a major building project, and not one for the faint hearted, so that inertia may also have contributed to their retention.

The robustness of the design and execution of the RSM is evidenced in the survival of these relict features and testifies to the strength of the well laid masonry and the general high quality of the building technology. The lowest strut above the entrance passage seems new and has been set in the plane of the higher scarcement (Figure 71). The original passage lintels, now represented by fragmentary tusking, lie in the plane of the lower scarcement. The



**Figure 71 (above)** Stacked voids above the stairway entrance.



**Figure 70 (above)** The stacked void above the entrance passage. Arrowheads indicate the scarcement surfaces.

top of the entrance's stacked void ends well short of the current wallhead. It is probable that the upper scarcement and the slapping-out of the original passage lintels are accommodations made to provide access to an infilled garth

(above). Certainly, the large breach in the outer wallface was made for this purpose. The modifications of the inner and outer wallfaces need not have been

**Figure 72 (right) The quality of the built wall at mid-height is very poor, with few or no panels of pinnings used to consolidate the masonry. The indicated panel sits within a structural crack and is therefore not original.**



contemporaneous but they are likely to have been so. The quality of the masonry build at mid-height in the inner wallface is especially poor (Figures 71-3) whilst that above it is quite serviceable. This is consistent with a reconstruction above a wall weakened by collapse.

Major cracks some splitting stones, but mainly opening joints, are visible in the inner wallface of Mousa (



**Figure 73 (left) The masonry of the inner edge of the entrance passage within the garth is, at best, shambolic and contrasts strongly with the build of the surviving inner wallface. The possibility that these are contemporaneous constructions is minimal. The lower scarcement can be discerned all the way to the arras, with a little faith.**



**Figure 74 Major structural cracks are clearly visible in the inner wallface. Note apparent displacement of the LHS wall of the second void in comparison with the lowest.**

Figure 74)<sup>134</sup>. It is clear that these are being monitored currently and that the cracking is ongoing. The cracks imply a circumferential spreading of the inner walls, possibly accommodated by the stacked voids which can absorb the net displacements<sup>135</sup>.

## **Towards a site biography**

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<sup>134</sup> I am grateful to Dr Theodossopoulos for his observation that the diagonal bottom end of the right hand crack in the illustrated example may indicate some settlement in the wall.

<sup>135</sup> **It seems clear from Figure 71 and**

Figure 74 that the (respectively right and left hand) edges of the stacked void (looking from the garth centre) are displaced towards the centreline of the void. However, the entrance ope has been remodelled so often that this observation needs to be treated with some caution.

The inner wallface of Mousa is a palimpsest of features built at different ages and in response to different structural ambitions. It is very probable that this was true even before the monument was refitted by the Vikings as a defensible citadel.

The changes in level of the entrance and the scarcements point to a raising of the floor levels following an episode of collapse and the re-establishment of a canonical broch at a higher level. It has been argued that the extraordinary thickening of the broch wall may be attributable to inner and outer relining, presumably following the significant failure, or failures, of the walls. The poor condition of the lower wallface and of the scarcements provide a measure of support for the probability of collapse episodes. Thus, the raising of the broch floor levels may have been coincident with a more general failure of the inner wallface which partly infilled the garth. The monument's present condition indicates ongoing instabilities.

The helical stairway isolates the galleries even though these had been converted to rectangular vertical sections and could have been usable storage spaces. It is unique amongst brochs and given the Viking requirement for a defensible fastness its unique qualities may, teleologically, but perhaps not improbably, be attributed to their interventions. The Iron Age stacked voids currently end at uneven heights at or below two floor levels under the current wallhead, which may indicate the approximate minimum height of the pre-Viking broch. This would have been a smaller structure, perhaps 2 to 4 m lower than it now is.

The survival of wallface features in the interior militates against massive thickening of wall by the use of an inner lining wall albeit that some relining has taken place. If the inner and outer walls had been convergent as the RSM indicates, the Vikings would have been forced to thicken the wall above the third level. It is probable that they worked from an irregular wallhead which they stripped to a variable level coincident with reasonable preservation of the extant fabric, and built up vertically above the battered *in situ* original wallface at mid height, to contain the helical

stairway. Subsequently circumferential forces have spread the new build and produced overhangs of the outer wallface.

Of course, it is possible that Mousa, an aberrant monument, was simply idiosyncratically built *ab initio*. Its survival owes something to its relative isolation, to which cause its idiosyncrasies could also be attributable<sup>136</sup>. However, this is highly improbable.

## Clickhimin Broch

Excavated by Hamilton between 1953 and 1957, Clickhimin yielded a wide and rich assemblage of materials, for which reason it is frequently cited in papers and books about the material cultural of the Scottish Atlantic Iron Age, see for examples; Charlesworth 1959, 44; Clarke 1970, 231; Robertson 1970, table 2; Stevenson 1976, 52-3; Guido 1978, 181; Topping 1988, 70 & 80; Owen and Lowe 1999, 175 *passim*; Smith 2002a, 809, etc. The excavations have been founded upon even more extensively as comparanda and for theoretical support of various and differing complexion; see for examples; MacKie 1971, 69-70; Lamb 1980, 13-20, MacKie 1983, 124; Lane 1988, 54-5; Carter, McCullagh *et al.* 1995, 22; Armit 1998, 100-1; Fojut 1998, 16-41; Sharples 1998, 136-38; Gilmour 2002b, 55-65; MacKie 2002; Crawford 2002, 114-120; Downes and Ritchie 2003, *passim*; Armit 2003, 28-30, 133-4 and Brundle, Home Lorimer *et al.* 2003, 96. Similarly, Clickhimin has featured in *corpora* and guidebooks, for example, in; RCAHMS 1946, 64-70, No 1246; MacKie 2002, 89-114; Cruden 1951; Feachem 1963, 155 and Hamilton 1983, amongst many more. On those occasions when scholars from south of the border write on Scottish archaeological monuments, Clickhimin is invariably cited (see, for examples Darvill 1996, 80-1, or Cunliffe 2001, 352).

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<sup>136</sup> It will be clear that the broch of Mousa urgently requires a more detailed building survey than is provided here and equally, that some of the issues raised above are capable of study by small scale interventions in its masonry. The raw data of an existing laser scan could with profit, be reviewed and informative imagery could be produced from it (R Strachan HES, pers comm).

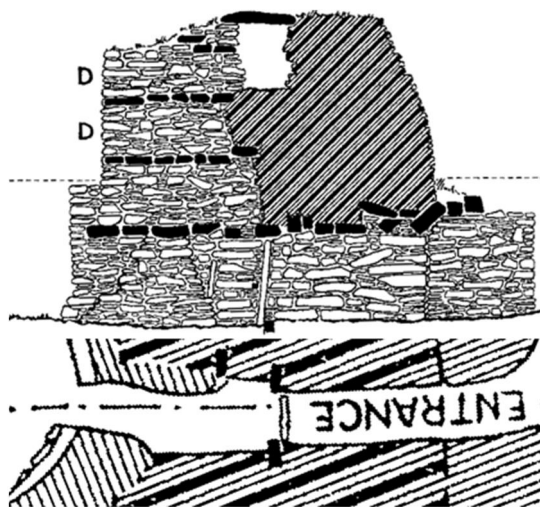
However, the majority of these writers rely in part or whole on Euan Mackie's interpretation of the monument, which differs in the detail from Hamilton's interpretation upon which it is founded. As noted elsewhere, Brian Smith's report on the monument at Clickhimin (Smith Forthcoming) criticises MacKie and others for their acceptance at face value of features in the monument which are demonstrably 20<sup>th</sup> century artefacts of heavy handed conservation efforts. This writer will not revisit this matter which is mainly significant for artefact studies and for the larger discussion of the place of the broch in the sequence of other structures on the site. The writer accepts that Brian Smith's account is irrefutable in point of detail.

The focus here is on the broch structure, and such evidence as it provides for its biography. It will be apparent that the monument was heavily modified in antiquity, as well as more recently (MacKie 2002, 93-6; Smith Forthcoming; Veloudis 2013-14). The question here remains, was there a simpler prototype from which the structure now surviving has developed or was the monument built in this aberrant way *ab initio*?

### The entrance passage

The floor plan and entrance passage of Clickhimin broch, surveyed by RCAHMS in the mid-1920s reveals a great deal of interference in the simple broch form.

Indications of the monument's biography can be discerned in the construction of the entrance passage as it now survives (Figure 75). At ground level, the pre-broch

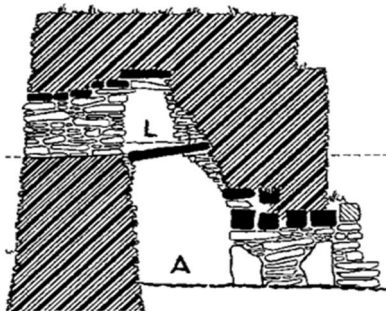


existence of a well-built wall is clear, indeed the outermost lintels of the passage rest upon it and over the building break between it and the rest of the masonry. Just inside the midway point of the passage two vertical stone slabs line

**Figure 75** Section through the broch wall at the entrance passage of Clickhimin, extracted from the RCAHMS Inventory (RCAHMS 1946, Vol 3).

an infilled ope that probably gave access to a guardcell. Historically, a bar hole was observed here also, but this has been lost to overactive maintenance. Above this level RCAHMS make a distinction between the outer masonry mass and the inner, and in fact, this masonry divide can be observed looking upwards between the lintels of the passage roof. It can also be seen in the stacked voids above the entrance, none of which was an isolated cell. The early wall and the ragged building joint up through the masonry are consistent with the collapse or down-taking of the broch wall and its subsequent reconstruction in a slightly different position.

The notional gallery on the uppermost surviving level above the entrance passage has been formed by building the outer mass, only to the line of the surviving wallface. This procedure is clear also on the opposite side of the broch, in the construction of Cell A (see Figure 76). The cell is formed by corbelling an outer shell against a more or less vertical wallface.



**Figure 76 Cell A at Clickhimin (RCAHMS nomenclature). The garth-side corbelled shell is propped against the near vertical outer wall fragment and lintelled over for closure.**

**Figure 77 (right) Modern wooden stairway access to the elevated ope and stairway.**

The gallery above the cell is similarly positioned within the wall thickness and invites the speculation that the outer wallface of the cell (LHS in Figure 76) may have been the sidewall of an original gallery, now subsumed into Cell



A. The redundant lintels over the inner end of the cell's passage. The stone slabs inset into the wallface of the cell's access passage are commonly observed in secondary structures in or around brochs and probably date to the second century BC



**Figure 78 (left)** The reuse of a stacked void, probably the original stair landing stacked void, to form an entranceway through the inner wall. The entranceway passage cut through the wallhead for about 600 mm and crossed the first level gallery void to exit the broch by a new ope slapped-through the outer walling of the monument.

to the second century AD. On the first level, at about 2.4 m above the current garth, a passage has been forced through the outer wall element to form a somewhat ragged entrance now more than 2 m access passage are all that survive of the stacked void over an earlier or original entrance above the

solum and accessed by a wooden ladder (Figure 77).

It is clear that the radial passage to the new ope was forced through a stacked void and across an early or, more probably, the original first level gallery, into the surface of which it has been cut to a depth of about 610 mm. The four lower steps of the stair, to the right of the cross-gallery feature just noted, are broken, dipping steeply down to the left and disengaged from the left wallface (Figure 79). The latter bulges outwards, towards the wall core and the masonry adjacent to the stairs bears clear evidence of episodic failure, repair and rebuild (Figure 79). The next 4 or 5 steps are relatively level but disengaged from the inner wallface. The inner wallface of the outer wall and the secondary ope, adjacent to the stairs similarly bear evidence of episodic failure and rebuild. Euan MacKie interprets the lower steps as secondary insertions, and while this is not impossible, it is much more likely that they are remnants of an earlier or original stair which did not survive, or were too damaged for reuse above this level.

Whilst some writers have treated the opening at the extant stone stair foot as a potentially original feature, it is on the evidence of the masonry, clearly secondary (above and MacKie 2002, 95) . Similarly, the extant stairs are treated as original and



the only structural stairs, but the anomalous Cell A probably originally contained a lower and now grubbed out staircase beneath and anti-clockwise of the extant one.

Cell A is highly anomalous. It has been characterised as 'corbelled' but it is not corbelled (Figure 76). Its garth-side wall has tipped inwards from about mid-height and is now jammed in position by the surrounding masonry. The lintels above it are



**Figure 80 (above)** The inner wallface of the outer wall at the secondary door. The lines indicate the more obvious fracture planes through the masonry which is clearly heavily reworked in this area.



**Figure 79 (right)** The stairway clockwise of the secondary entrance. Note the significant bulge outwards in the LHS sidewall of the stairway. The stairs are not all of one build.

all displaced. It would have been impossibility to form this cell in drystone masonry. It is a built structure frozen in the process of decomposition and bodged into a cell by subsequent builders.

The wallhead at Clickhimin is heavily restored and has been heightened in some places and truncated in others. Similarly, the inner wallfaces are a palimpsest of modifications, each adopting some part of its predecessor's masonry and removing other parts. None of the observations made above, nor those others made but not detailed here, is entirely new or un-noted hitherto. Rather, the prevailing paradigm has required writers to interpret the surviving remains as if they formed a coherent



**Figure 81 (left) Cell A. The wall on the right is probably an original gallery wall. The LHS wall is topped with what has been called corbelling. However, this masonry has simply fallen inwards and wedged in place now apparently stabilised with mortar. It is not a drystone built feature and cannot have been one, given the sloping joint planes.**

set of structures and modifications upon a loosely -broch-typeø monument. It is concluded here that the remains subsume a broch tower of RSM type, overlying earlier structures some of which it also subsumes, and suffering at least one major catastrophic failure, following which it was reconfigured, as a broch. Subsequently,



**Figure 82 (left) The tertiary entrance at Clickhimin. Rispain joints isolate the block of masonry immediately below the entrance, which may have extended down to the level of the masonry abutting the broch left of the ope; but note earlier repairs below this level.**

the floor levels inside and out rose by about 2 m requiring a new entrance, forced through first floor of the stair landing stacked void. Then, or later again, the now-wallhead gallery void became infilled in part, creating a ramp of material that rises by c 0.6 m across the monument. The failed Level 1/2 stairway was rebuilt to give access to the raised walkway formed partly within the extant gallery void and partly

in new masonry (Figure 82). A tertiary entrance was cut from the wall walk through the outer wall. Now too small to serve as an effective entrance, the masonry below it in the outer wall indicates that it was larger at one time, probably extending as low as the stone slab that juts from the broch wall on the left of the image in Figure 82 and even that is built upon earlier modifications.

The writer does not pretend that the above is a full biography of the surviving masonry, which would take a much longer narrative than there is space for here, but hopes that enough has been demonstrated to support his conclusion that nothing now surviving at Clickhimin precludes an RSM ancestry and as noted, several features point to that conclusion however complex and atypical it now appears.

## Midhowe broch

Midhowe broch was excavated by W G Grant over a five year period and published with the assistance of J G Callendar (Callander and Grant 1934). The actual work of excavation was undertaken by one man (James K Yorston) who tipped 1500 to 2000 tons of debris over the nearby cliffs, together with a great deal of the monument's primary evidence. The monument before excavation was a grassy mound with occasional stones visible in the sward, as North Howe now appears (Figure 83<sup>137</sup>).



**Figure 83 The structure top left of this plate encloses the Neolithic Chambered Cairn of Midhowe. Midhowe broch is near the centre and the grass covered mound with some stone showing, bottom right, is the broch of Midhowe North. © RCAHMS**

The exposed Midhowe structure is clearly the remains of a broch ranging from 2.13 m high near the entrance to some 3.05 at the rear;<sup>138</sup> measuring, externally, 18.14 m NE to SW by 17.68 orthogonally to that: whilst elliptical it was considered near

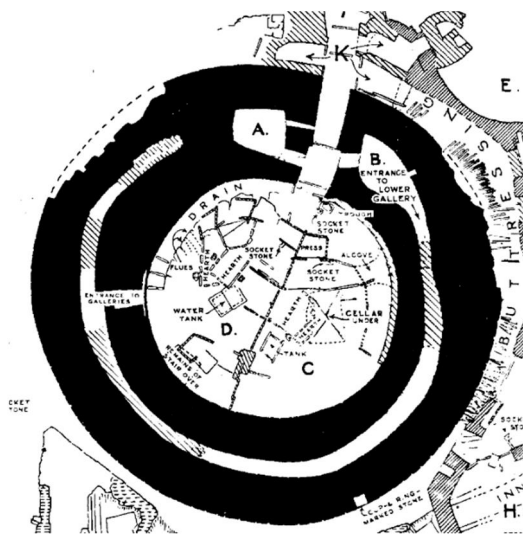
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<sup>137</sup> From <http://canmore.rcahms.gov.uk/en/site/2276/details/rousay+north+howe/> Image DP056433 © RCAHMS. accessed 13/03/2015

<sup>138</sup> Some of the dimensions quoted in this section are conversions from the feet and inches, in which they were reported, to metric equivalents. In consequence they appear spuriously precise ó to the nearest centimetre ó when the nearest 5 cm is probably more appropriate.

enough circular. The inner garth measured 9.81 m by 9.5 m on the same axes at around 600 mm above solum. Averaged over the circuit, the wall thickness was therefore approximately 4.13 m, albeit that it averages 4.5 m thick at the entrance. The internal garth diameter averaged 9.65 m and the external, 17.91 m. A moment's perusal of the plan (reproduced here as Figure 84) will reveal that the outline of the external and internal wallfaces of the broch is irregular and since both walls are now significantly out of the vertical, their horizontal dimensions vary with height. Thus, the published measurements cited above cannot be relied upon<sup>139</sup>.

## Location



**Figure 84 Midhowe Broch at ground level**  
(After Callander and Grant 1934, Plate VII)

The broch of Midhowe is one of 12 such monuments disposed on either side of Eynhallow Sound, a narrow passage of water between Rousay and Mainland Orkney subject to extraordinarily powerful tidal currents. Midhowe is one of the six monuments on Rousay and the center of a local group of three that lie within the compass of 500 m along the coast of Westness. This is one of several such close groupings (see Keiss group for comparison Heald and Barber 2015, 85-7) whose associative values with their

neighbouring monuments greatly increases their cultural value (see for example Armit 2005b for discussion of familial succession in such groups). Midhowe is sited on a small promontory defined by two deep, vertical-sided geos, or channels. On the basis of no evidence, its excavator and publisher concluded that the broch and the

<sup>139</sup> It should be noted that the published surveys followed traditional archaeological practice in recording the base line of the wall, except where any point on the wall overhung it, in which case the orthogonal projection of the overhang on to the survey plane was recorded. Thus, the published plans do not record the footprint of the broch but rather, are interpretations, representing something that has no real-world physical existence.

massive stone wall across the neck of the promontory were contemporary (Callander and Grant 1934). Somewhat flimsy structures were built inside and around the outside of the broch and these were, they believed, later than the broch tower proper (Callander and Grant 1934, 445-6).

### **Excavation**

The excavation comprised the emptying of the broch structure and included the removal of vertically-set slabs that had been used to pack the deformed ground gallery, the side of which were bulging inwards along the northern, and parts of the southern, circuit of the wall. Vertically-set slabs were also stacked around the northern circuit of the broch wall. The surrounding village of slight structures was also cleared of debris.

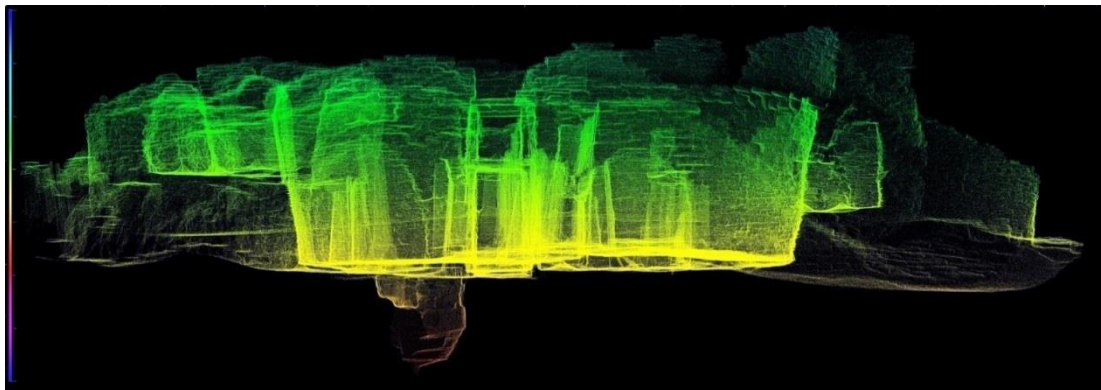
### **Review**

John Hedges' review of the excavated evidence (Hedges 1987) added little to the factual basis presented in the Callander and Grant report. Hedges' only disagreement on structural matters lies in his scepticism that the high level cell blocked the upper gallery and was thus a secondary feature (discussed below). Euan MacKie's account of Midhowe is best expressed in his 2007 synopsis, in which his disagreement on several points of structural detail are set out (MacKie 2002, 233-240). These are summarised here for their relevance. MacKie queried the chronological relationships between the broch, the massive stone wall and the slight buildings around and in the broch and offered alternative readings, on no new evidence.

To his deliberate demolition episode he also attributes the infilling of the ground floor gallery and the stairfoot cell with upright slabs. He believes that the septum and internal stair replaced a putative original wooden structure and the wallhead had been reduced to about its current level before the interior of the broch was thus remodelled. He queries whether the Inner Lining Wall (ILW) functioned as a buttress and he favours its interpretation as facilitating the construction of the slight inner buildings. On the basis of these observations and interpretations, MacKie proposes a 'plausible sequence of events'. He suggests that Midhowe began as a fortified farmhouse; built as a residential stronghold possibly 12.2 m high, behind a forework

and ditches and with no surrounding buildings: he accepts that the ditches could be pre-broch. Sometime later, the basal gallery began to lean outwards and was then packed with stone. MacKie notes that the original report suggests that the blocking was inserted much later. An undefended settlement was built when the broch tower was still intact but after the gallery blocking and when there had been a dramatic lessening in the need for defence. Finally, the decision was taken to demolish the broch to a safe height and rearrange the interior. Some of the down-taken lintels were piled in the passage between the broch and the outbuildings.

### Anatomy of the structure



**Figure 85** View through the point-cloud of the laser scan of Midhowe broch.

In the brief review of the commentaries on the excavated evidence above, reference has already been made to many of the features of the broch and its environs. Those relevant to this study are hereunder listed, described and illustrated.

The broch tower is a three-dimensional structure and the relative heights of its several parts are important, not least because horizontal measurements, like the external diameter, vary with height. It would be valuable to know the ground level from which the broch was first constructed. With the exception of MacKie, earlier writers seem to have uniformly assumed that the visible solum is the original solum although the reporting authors clearly state that some 460 mm of material was left *in situ* over the original floor to preserve 'important structures'. This is confirmed by the laser scan of the broch undertaken for this study (Figure 85). The floor of Midhowe is dish-shaped upwards at its center and lowest around its perimeter (Figure 85).

In addition, the perimeter of the broch is clearly horizontal in the 12 to 6 o'clock semicircle. In this area a drain runs immediately beside the wall foot and this, it is hypothesized, could have been used as a reference level to ensure horizontality in building.

### The garth

The excavation report records the search by the excavator for the original central hearth by probing the 18ö (460 mm) of material left unexcavated in the central garth to preserve the internal fixtures and fittings of the monument (Callander and Grant 1934; 455). Indeed, MacKie's belief that the flagstone floor of the inner part of the entrance passage is secondary relies on that observation for its logical veracity (MacKie 2002, 235). Hope, cited by Armit 2003, 73-76, suggests that domestic activity was sited at the first-floor level and this is unexceptionable, but the evidence on which Armit founds his support of this view is tenuous indeed. It requires the acceptance of a primary wooden structure within the broch based on slight evidence which Armit had already rejected (Armit 1998, 111-2). Furthermore, hearths are found at all levels in brochs (see Curle 1921 re Dun Troddan), including on the top of a roughly 3m high stone cell built within Midhowe (Chapter 6) and the selection of the first floor as the necessary and exclusive locus of the primary hearth is rather arbitrary. Conversely, of course, MacKie has repeatedly asserted that hearths on the OGS are underrepresented in the archaeological record because excavation usually ends above the original ground level (see for example Callander and Grant 1934, 455) but note Fojut's rejection of MacKie's proposal: (Fojut 2005b, 192-3)).

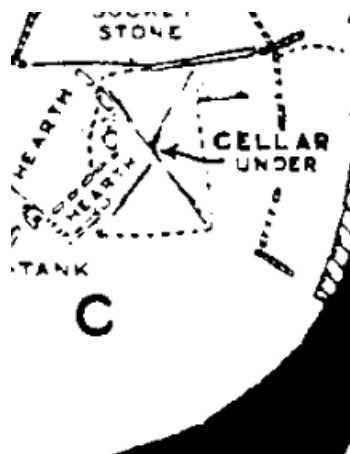


Figure 86 (left) The well/cellar overlain by a septum slab (and hearth

#### The well

The excavation report notes that the base of the rock-cut well or cellar lies 2.59 m below the current solum, with its top 760 mm formed in part of built masonry. It is covered by two large flagstones and one of the septum slabs together with part of the surviving hearth



overlap the margins of these flags. Now empty of water, it seems unlikely that this void ever contained much, given its adjacency to the sea cliff. The location and shape of the notional well can be seen in the scanned image (Figure 86)

### **The mural structures: number and position**

The number of galleries is variously cited as three, or two with an intermediate gallery. There are three observable voids within the thickness of the wall, the ground gallery and the mid-, and upper-voids.

### **Floor levels**

The floor of the Ground Gallery is 100 mm higher than the adjacent entrance passage which may be 50 to 100 mm lower than the general level of the garth (MacKie 2002, 234). This should place the current gallery floors about level with the current garth. However, the recorded sections show the gallery floors between 600 to 1200 mm higher than the garth solum. This is credible given the excavators' prudent fears for the safety of the galleries following their removal of the edge-set stone packing. It is assumed that original deposits survive in these gallery floors.

### **The ground gallery**

This is illustrated in sections and plan in the excavation report (reproduced here as Figures 88 & 89) and illustrated in photograph (Figure 87). Currently its wallfaces, outer and inner, bulge significantly into the passageway and some of its lintels are displaced or broken with fresh stone fallen onto the current passage floor (in 2015). This gallery encircles the broch at ground floor level, albeit apparently now unconnected to the RHS guardcell from which it is said to end 1.5 m distant (see  $\varnothing$  on Figure 89). There is no doubt that this, the lower void, is a ground gallery.



**Figure 87 View along the ground gallery from the LHS guardcell**

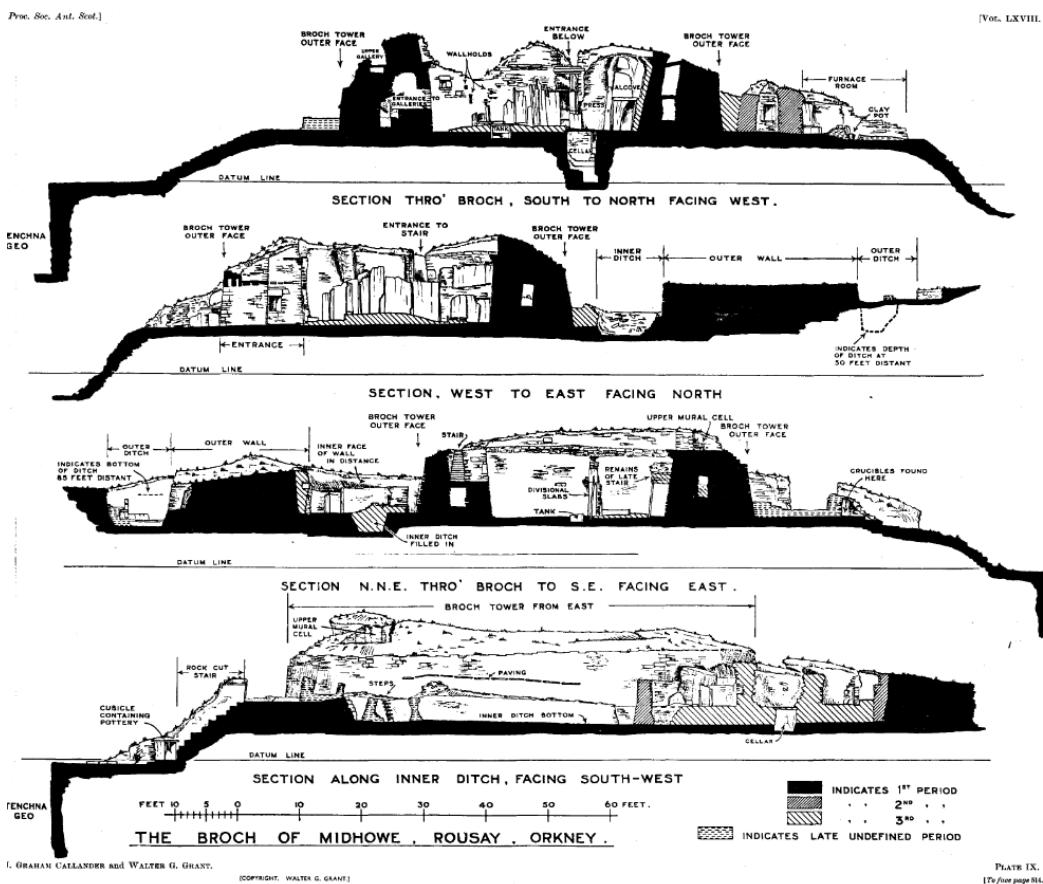


Figure 88 (above) Cross sections from Callander & Grant 1934

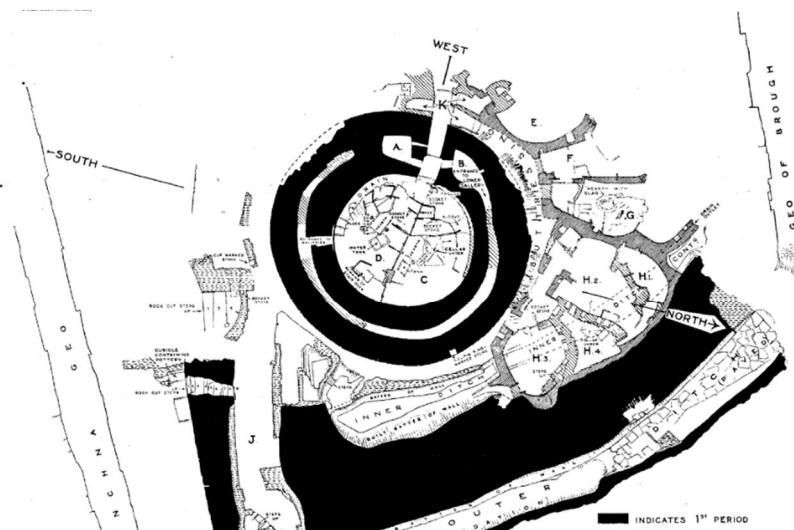
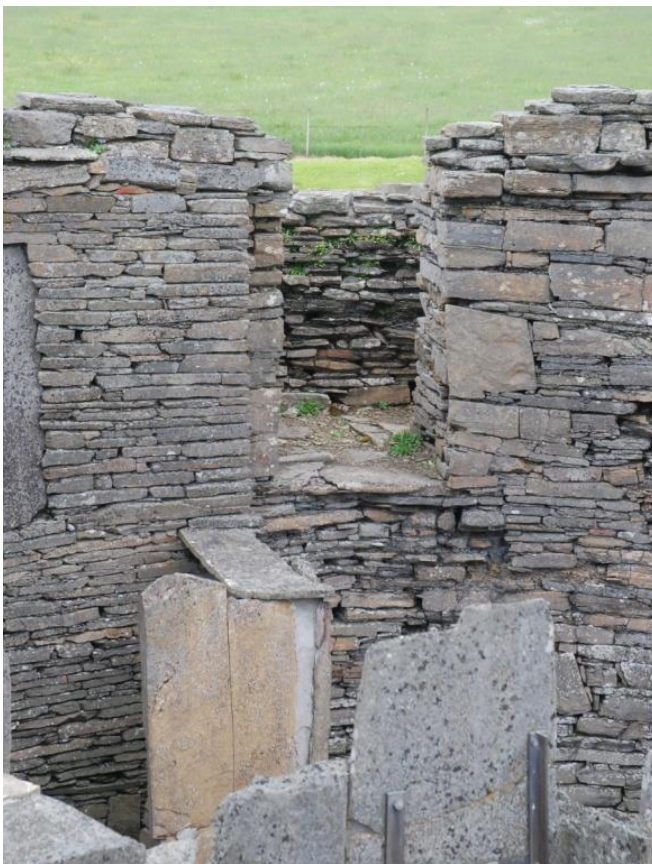


Figure 89 (left) Ground plan (Callander & Grant 1934)

### The mid or intermediate void

The entrance to the mid void is visible opposite the stair foot, in the Inner Wall at the half past nine position. The stairfoot features require some clarification. The ope from the garth, at first floor level lies about 1.5 m above the current garth floor and is flanked by two, possibly diachronic, elements. Its RHS (looked at from inside the broch) is fully engaged with the IW masonry in which it is set, and it inclines gently towards the midline of the ope as it rises (Figure 90). This is interpreted as the original RHS side of a stacked void, The LHS side of the ope is vertical, but, when viewed from behind (Figure 91), is revealed as the face of a masonry block abutting an earlier masonry return. The side wall of the adjoining gallery (the pear-shaped gallery) leans inwards at about 15 degrees out of the vertical.



**Figure 90 (left) The ope to the first floor-level, accessing stair and cell**



**Figure 91 (above) The back of the left edge of the stairway ope. Note the building break between the vertical masonry pier and the inward leaning side wall of the gallery.**



**Figure 92** The masonry directly under the ope is badly disarranged and it is likely that it blocks a door ope that gave access to a ground floor gallery or a ground floor stairway, possibilities that can only be tested by excavation.

**The 'pear-shaped' cell of the mid void**  
The void opposite the stairfoot (

Figure 93) opens into a pear shaped cell (shown in hyphenated outline on North, i.e. right side of Figure 94). It is up to 1.5 m high. The pear-shaped cell is not concentric with the original gallery on this level and it



**Figure 93 (left)** Entrance to the intermediate gallery, now inclined to the outside of the broch by an average of approximately 15 degrees.

approaches the IW wallface of the broch very closely. Its shape and disposition are atypical of broch wall cells. At its widest, the pear-shaped cell veers towards the inner wallface deviating from the line of floor lintels, as can be seen in Figure 94.

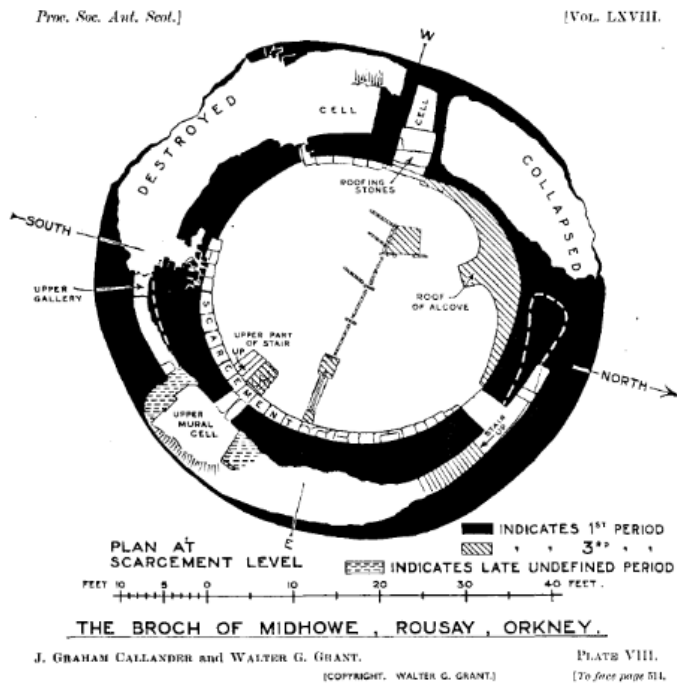


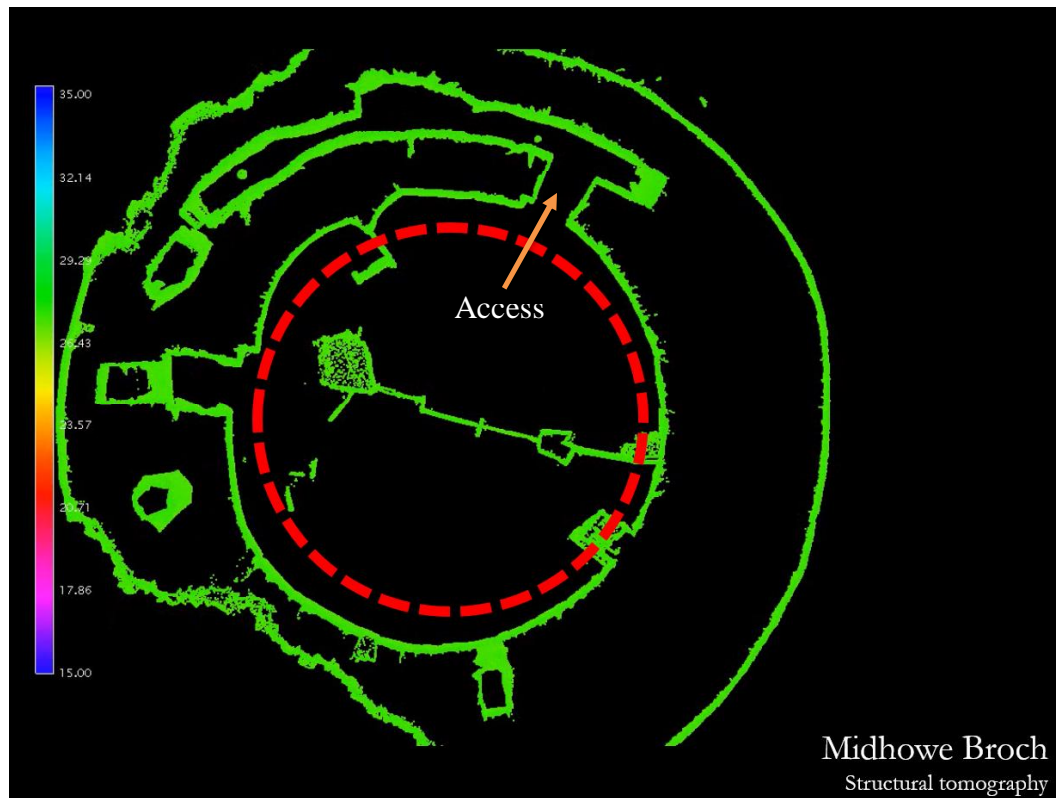
Figure 94 Plan of second and third floor features at Midhowe, after Callander & Grant 1934. The 'pear-shaped cell' is marked by a broken line, below centre right of the image.



Figure 95 (left): The entrance to the pear-shaped cell from the stairfoot showing divergence of the left hand wall from the floor lintels of the original gallery.

These floor lintels are also the roof lintels of the ground gallery and would have been the floor of the original first level gallery. The first level gallery side wall should then overlap the edges of these lintels. The pear-shaped mid-void is therefore not a broch gallery and is a non-canonical form. It is very roughly corbelled and re-joins the original gallery further anti-clockwise,

via a crawl-way (just visible in Figure 95, left of centre) that runs on towards the entrance. This continuation of the gallery is not represented in the excavation plan (extracted here in Figure 94).



**Figure 96** A still from the structural tomography video at about 1.95 m above the centre of the broch floor. This shows (top) the pear-shaped cell (a souterrain) and its crawlway which merges with part of the original gallery.

It is argued here that the pear-shaped cell is a secondary insertion into the crushed and distorted first level gallery area (Figure 96). It is hypothesised that the pear-shaped cell was inserted when the broch had already become a rubble mound and settlement had extended over it. It is envisaged that observation or discovery of the stairway induced the later settlers to rebuild the rubble at its stairfoot to form a cell, which to them would have been a souterrain, an underground cell putatively used for storage. Souterrains are a common Iron Age and Early Medieval monument type<sup>140</sup>

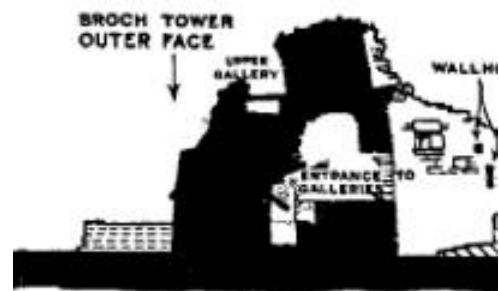
<sup>140</sup> Souterrains are a common Iron Age (in Scotland) and Early Medieval (in Ireland) monument type whose identification in Early Irish Literature (*cf.* Lucas, A T (1971). "Souterrains: The Literary Evidence." *Béaloides* 39/41: 165-191.) has biased their interpretation as Early Christian monuments in Ireland and perceived associations with Pictish monuments in Scotland has had a similar effect. In general they are dated in Ireland to the second half of the first millennium AD and the earliest centuries of the second millennium AD (see O'Sullivan, M and L Downey (2004). "Souterrains." *Archaeology Ireland* 18(4): 34-36., for a gentle introduction). They are sometimes associated with

whose identification in Early Irish Literature (*cf.* Lucas 1971) has biased their interpretation as Early Christian monuments in Ireland. In general Irish examples are dated to the second half of the first millennium AD and the earliest centuries of the second millennium AD (O'Sullivan and Downey 2004). Conversely, Scottish souterrains are less numerous than their Irish counterparts and seem to date primarily to the Iron Age, rather than the early medieval, period, as the ScARF Iron Age panel report indicates:

Souterrains vary in date from the Late Bronze Age/Early Iron Age in the Northern Isles to the Roman Iron Age south of the Forth, with a presumed floruit in the last centuries BC and first two centuries AD (Armit 1999; Miket 2002). There are differences in construction and dating across the areas of occurrence, but similarities in conception, situation and material assemblages imply links in terms of their function and behaviour. Composite ritual and storage functions (Henderson 2007a, 142-7) have been argued although such a composite functional interpretation may not be sustainable for all areas (see Dunwell and Ralston 2008 on Angus souterrains versus Carruthers on Orcadian examples). (ScARF 2012, 57)

The broch at The Cairns in South Ronaldsay, Orkney, now under excavation, has had a souterrain inserted partly into the entrance passage and extending out from there into the debris field of the monument which was at or above the level of the surviving wallhead when the souterrain was inserted (observed on site, with thanks to Martin Carruthers).

**Figure 97** The supposed ‘entrance to galleries’, giving access to an irregular intramural void, to the top of the damaged ground floor gallery and, above and left of that, to an eccentric upper gallery, or souterrain (extract from Figure 6.30).




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pre-existing monuments including major Neolithic mounds, like Knowth and Dowth in Ireland and with brochs in Scotland.

The pear-shaped void is identified here as a souterrain probably of the first half of the first millennium AD, inserted when the broch at Midhowe had been reduced to roughly its current wallhead height and had later been subsumed within its own debris field. It is not an idiosyncratic or non-canonical upper gallery as the excavator and Hedges imply, but a secondary intrusion into the space left by a damaged or lost upper gallery.

### **The intermediate gallery**

An intermediate gallery is apparently revealed in the published West-Facing, South to North section where the 'doorway' at c. 3 o'clock cuts into the bottom of a void identified by the excavator as an 'intermediate gallery' (Figure 97). The irregularity of this 'gallery' is clearly discernible - and the entrance pushes through its base to cut into the top of the ground gallery.



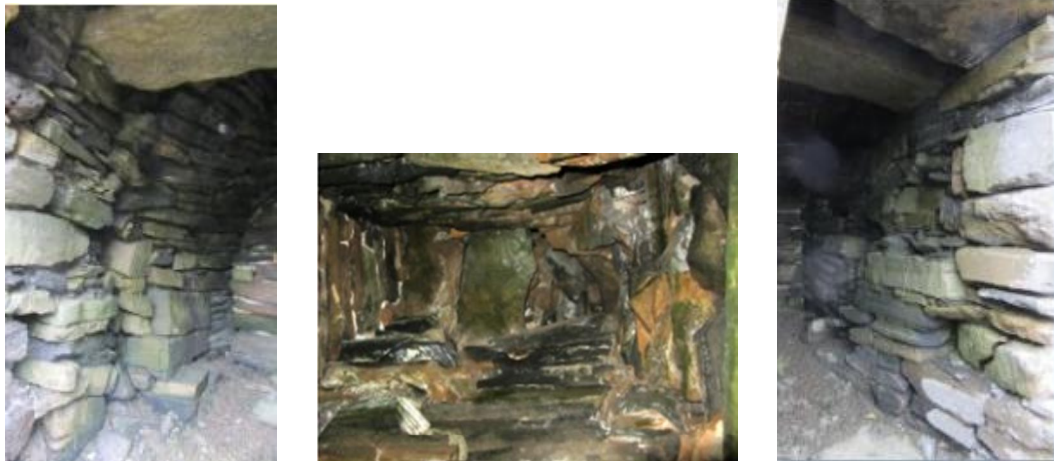
Figure 98 (left) The 'Entrance to galleries'

In contrast, the galleries on the north side of the broch (see Figure 88) although distorted, were regularly built and clearly set one above the other. Taken at face value, this section seems to demonstrate that the 'Entrance to Galleries' accesses a volume of traumatically failed fabric within the wall, rather than a built gallery. This is consonant with the outward tilt of the second level masonry above it to the right, and consonant also with the general condition of the lower gallery which indicates major deformation of the wall.



## A structurally redundant stacked void element

The feature, described in the excavation report as an ‘Entrance to galleries’ is located on the south of the IW about 1 m above the current garth level (?). The creation of a door to access the top of the ground gallery and the foot of the putative intermediate gallery is rather odd. More recently this has been described as an entrance to a wall cupboard or aumbrey.



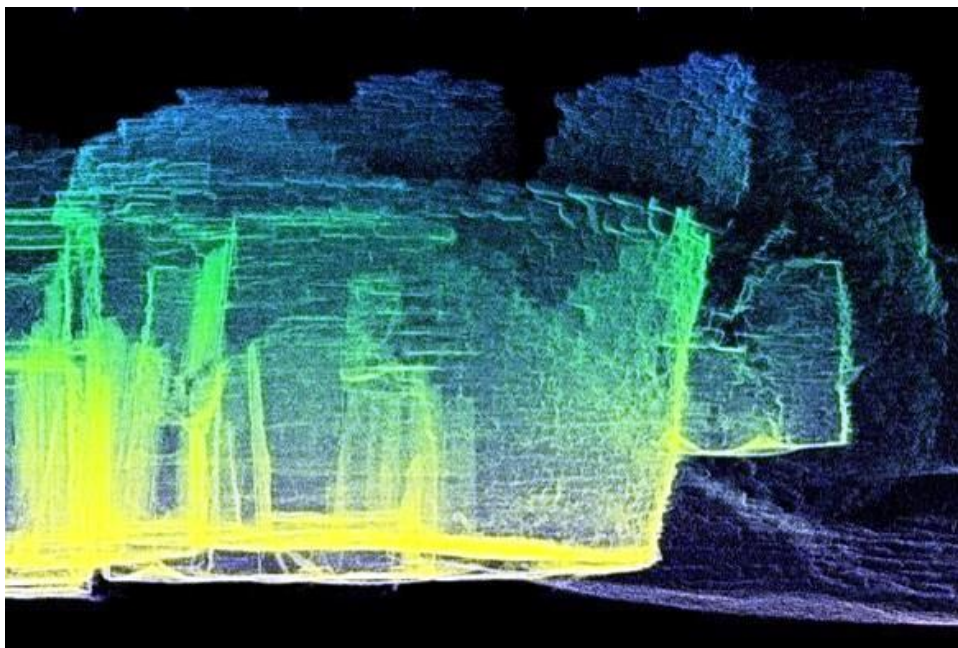
**Figure 99** The side walls and a view up into the ascending limb of the ‘aumbrey’. In the latter view (centre) the reverse of the inner wall of the broch lies at the bottom of the image.

the base of the aumbry. The surviving structure lies just clockwise of the collapsed outer wall and its infilling and reconfiguration may have been part of the response to that collapse.

The rear wall of the void is a mortared wallface either inserted or consolidated as a ‘conservation’ measure following excavation. This should be the inner wallface of the outer wall but probably is a repair to the breach in that wall implied in the excavation account. The laser-scan data reveal the gross morphology of this feature. On the right of the image, the shape of the void can be seen to enter the wall approximately horizontally and then turn upwards to a level just under the upper, secondary, high-level scarcement. This vertical shaft leaves little doubt that this structural element was originally a stacked void, accessing the intramural void, and rising through the wall thickness.

Viewing the inner wallface feature as an element of a stacked void makes sense of the mismatch between this ope and the galleries behind it because the void ope in a stacked void are not all coterminous with the gallery spaces (see Glenelg or Mousa, *passim*, for examples). It also explains the upward projection of the void space seen in Figure 100 which is not explained by its interpretation as a doorway to the galleries or a cupboard or an aumbry.

The existence of the relict, stacked void indicates that the Inner Wallface of the broch has been stripped down to at least the top of this ope at some point and then rebuilt above the surviving ope. Comparison of the height of the surviving intramural void



**Figure 100** Point-cloud image; the aumbry on the right enters the wall horizontally and rises vertically within the intramural void. Note the high-level scarcement, dipping towards this side and built into the masonry overlying the intramural void.

space suggests that it has been capped off below the extant high-level scarcement (see Figure 85 & Figure 100). It is clear from Figure 98 that the masonry around the void ope was very heavily cracked and broken and its down-taking would only have required a local intervention. However, this further implies that the high-level corbelled scarcement here cannot have predated the resurfacing of the IW in this area. Thus, the high-level scarcement was not a feature of the original broch tower. It

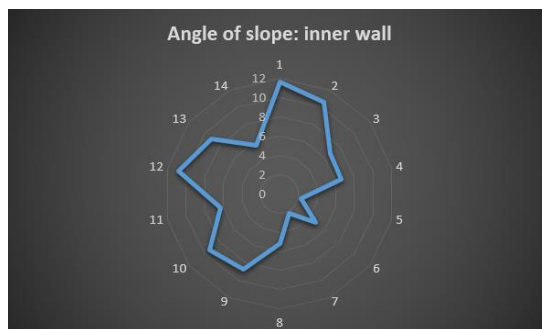
is assumed that the original scarcement lay at the level of the entrance passage lintels and has been removed in repairing and or replacing the inner wallface.



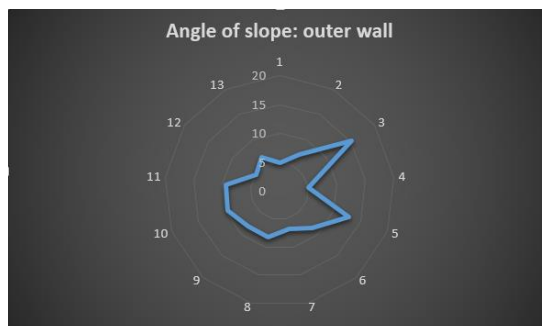
**Figure 101 The entrance façade**

As discussed in Chapter 3, the engineering and architecture of the entrance is the most complex part of a broch and its masonry is subject to the greatest stresses. The external face of the Midhowe entrance is well formed and apparently unaltered by the failure of the outer wall on either side of it. The entrance ope and its enveloping masonry are centered within the area of greatest structural deformation.

The survival of the entrance façade is localised to c. 7 m to the left of the entrance where the external buttressing, underpinning a sagging wallface, begins and to about 5 m to the right, where the breach in the outer wallface begins. At the junction of the



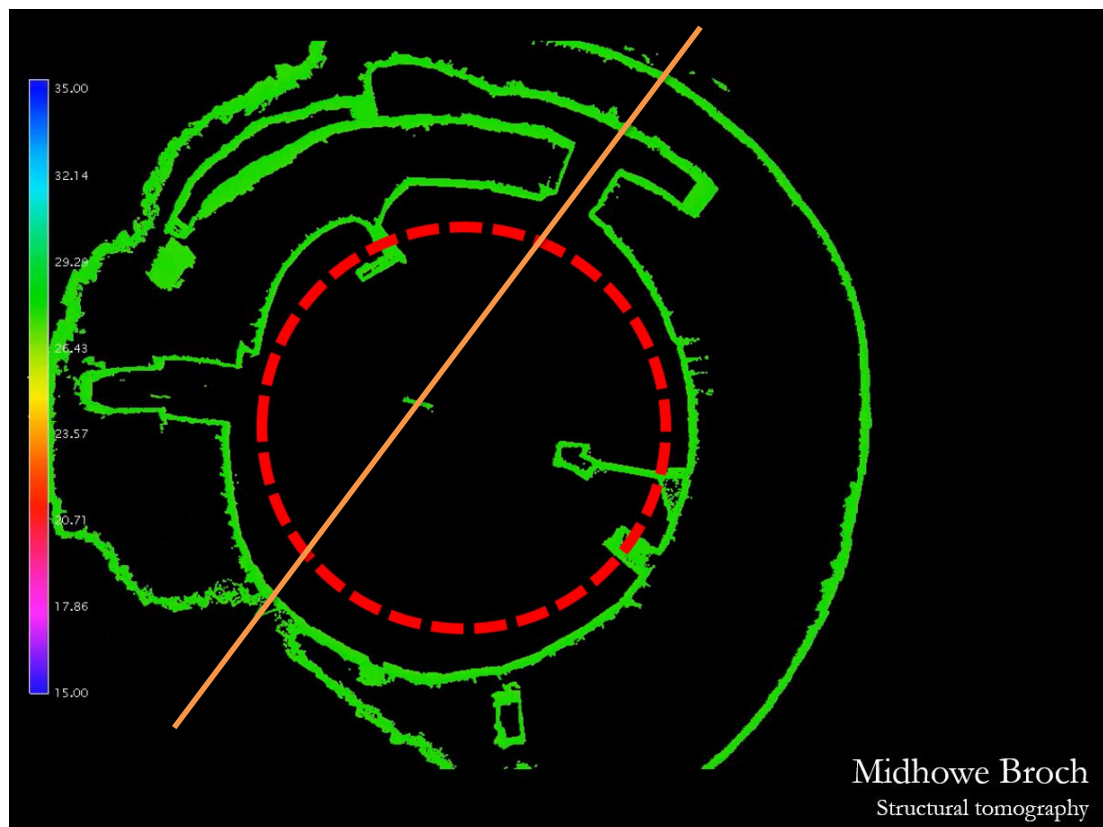
**Figure 102 The angular displacement from the vertical of the Inner Wallface. The concentric circles are at 2° intervals.**



**Figure 103 The angular displacement from the vertical of the Outer Wallface. The concentric circles are at 2° intervals.**

facade and the breach the stones of the upper part of the apparently intact masonry make an angle of c. 5 degrees with the stones of the lower part of the exposed profile. This is not a large discrepancy but given the tight control of horizontality exhibited in brochs in general and elsewhere in this example, it raises the suspicion that the entrance face has been re-engineered into place over the margins of the breach to its RHS. This might explain why the stonework above mid height at the outer corners of the entrance passage differs from the lower courses and why the RHS corner projects further out than its opposite number. In simple terms, the entrance façade has been rebuilt.

Figure 102 illustrates the angular displacements of the IW of the broch outwards from vertical placement above the wall foot, with the entrance placed between positions 14 and 1 at the top of the image for Figure 102 and Figure 103. In general, this records the least deformation opposite the entrance and the maximum, over  $11^\circ$



**Figure 104** This image comes from the tomographic analysis of the structure and represents a horizontal segment of the structure some 2 m above the central solum. The green lines trace structural margins and the red broken-line marks the relative position of the wallfoot. The diagonal line is the axis of maximum distortion by out-throw.

out of true, on either side of it, but only moderate damage, 5° in the entrance area itself. This is consistent with the conclusion reached above that the entrance area is largely rebuilt.

The net displacements of the outer wallface (Figure 103) are somewhat more complex, with parts of it leaning inwards and parts outwards, but it tells essentially the same story. The largest displacements lie on either side of the entrance area. It should be noted that the area anticlockwise of the entrance contains the major breach in the outer wall and so shows minimal displacement on this illustration although it is the area of maximum displacement; the wall fell outwards. The outer wallface is closest to vertical at the entrance area<sup>141</sup>. It is very improbable that the entrance area was unaltered by the episode of general collapse evidenced at this broch and for this reason, and given the very clear flattening of the entrance façade, it is concluded here that the entrance area was rebuilt following its collapse<sup>142</sup>. It may be argued that the existence of the external Structure(s) K (see Figure 89) could have provided some buttressing for the entrance area and K may well have protected the lower levels of the entrance. It is however too small and too slight to have resisted a major collapse and indeed, for the same reason, it is improbable that it would have survived such a collapse itself. It is argued here on the balance of probabilities that Structure K postdates the monument's collapse and the entrance reconstruction.

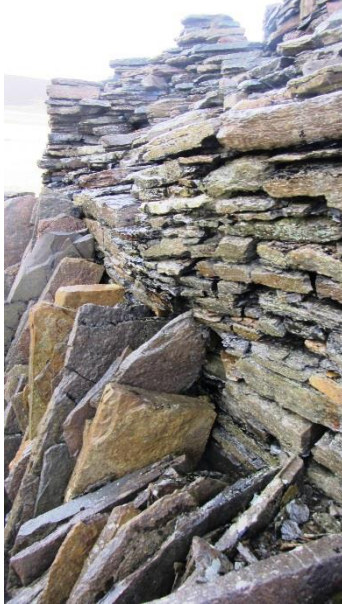
In brief, and as Figure 104 shows, the upper inner wallface was displaced outwards all around its circuit, with the greatest displacement in the surviving remains along the axis indicated by the red diagonal line. Given the distortion of the ground gallery, it is tempting to attribute the damage mainly to self-load, possibly amplified by wind forces, creating stress levels greater than the structure's ability to cohere (see Chapter 8 for fuller discussion). The outer wallfaces are universally lower than the inner and

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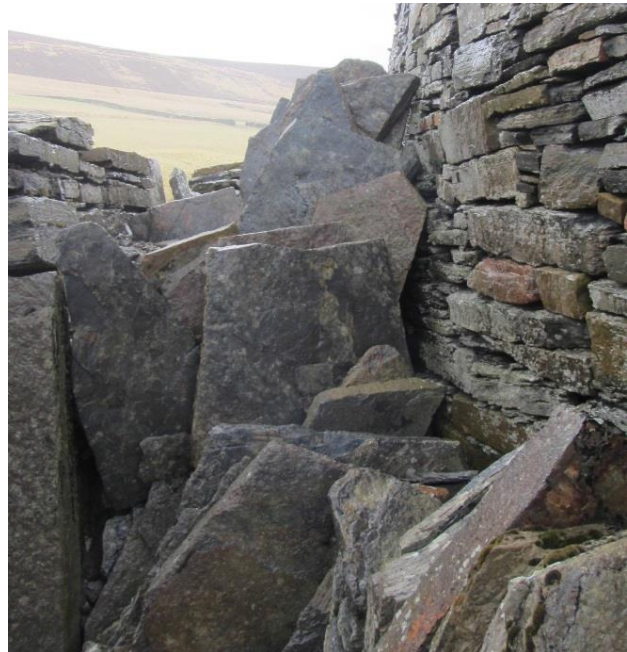
<sup>141</sup> The entrance lies between radii 1 and 13, and the radii at 8 and 9 which were inaccessible on site, have been stated as the averages of points 7 and 10.

<sup>142</sup> The impact of conservation works in the area should not be forgotten. Concrete has been used to reassemble parts of the structure above the entrance passage and further reconstructive conservation is likely to have taken place.

if not all attributable to later stone robbing, indicate a general outwards collapse. However, it is necessary to think of the inner wall as a tube of stiff fabric which, forced to buckle near its base along one axis forced the fabric at right angles to bend outwards, while the upper and opposite parts of the tower fell into the garth.



**Figure 105 (left) Slabs propping the broch wall anticlockwise of the entrance**

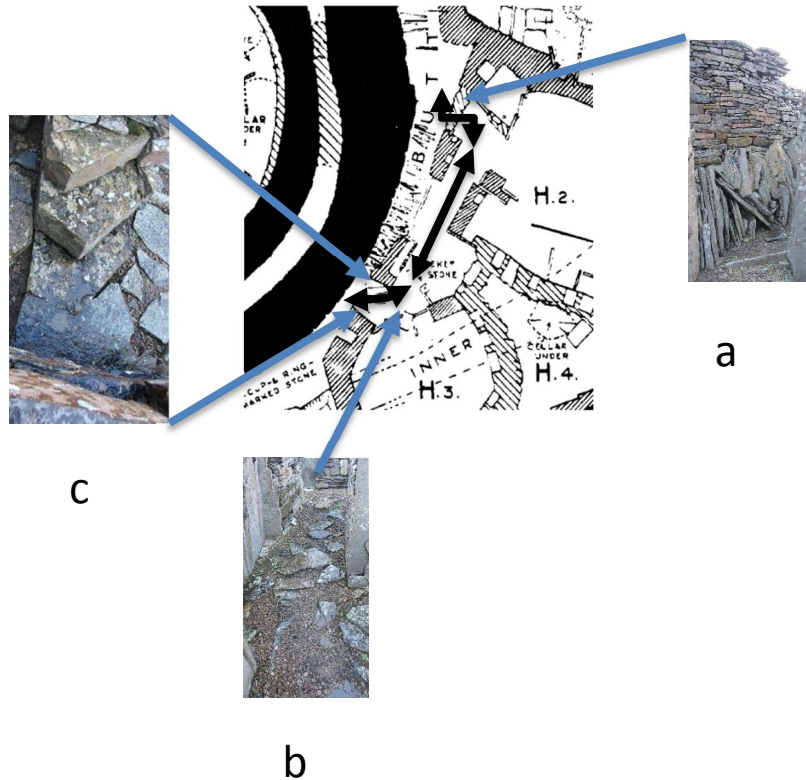


**Figure 106 The buttressing slabs (right) have transferred some of the force from the bulging wallface to the wall face on the left which was once part of structures H 2, 3 and 4.**

### **The buttressing slabs**

The slabs leaning against the outer wall left of the entrance on the north side (Figures 104 & 105) have been interpreted as buttressing (Callander and Grant 1934, 446-8), and alternatively as stockpiling of useful material during a manual down-taking of the broch tower (MacKie 2002, 237-8). Close inspection reveals that the outer wallface bulges out dramatically and is, indeed clearly propped by at least some of these slabs. Further, it is clear that outward pressure has moved not only the slabs but an existing wall outside them (Figure 107).

The slabs blocked the passageway adjacent to the broch wallface, forcing alterations of the structures, H2, 3 and 4 to provide an alternative route past the broch. These observations imply that the condition of the broch continued to deteriorate after these structures had been built, to protect against which, the slabs were in fact inserted for



**Figure 107** Circulation along the passage bordering the broch's outer wallface was blocked by the insertion of the stacked slabs (a) requiring the formation of a 'corridor' within structures H2 to H4 (b) and the breaking out to wallfoot level of an exit at (c); all undertaken to form the new circulatory path indicated by the black arrows.

buttressing, a function they continue to perform. Alteration of the circulation in this area is inconsistent with the simple storage of useful slabs against future need because the alterations to the H2 to H4 structures was not a trivial undertaking (see Figure 107).

### **The entrance passage from within the broch**

The relevant features to this discussion are visible in Figure 109. These include the chamber above the passage, the innermost edge-set lintel and the three flat lintels of the passage roof and the tussing (on the image's left side) of, probably three broken and lost lintels and (on the right) the voids and broken stumps left by their destruction and removal. Above these features a single triple-decker stone beam spans the stacked void of the inner entrance. Above this in turn, a ledge can be seen on the right, which forms part of the upper scarcement.

The entrance passage was originally lintelled along its full length at about 1.9 m above solum, but the innermost lintels have been slapped out at some stage leaving tuskings (projecting stumps) on one side and gaps with broken stumps on the other (Figure 108). The three outermost lintels formed a composite beam to carry the mass of the outer wallface and were either massive (the first one) or set on edge (the inner two). This and the thin slabs of the rest of the lintel table are illustrated in the excavation report, from which Figure 109 is an extract. This also illustrates the upper lintel table, level with the top of the triple-decker stone beam. However, it does not record the socket or the opposing tuskings of the lost lintel/s that had filled the gap between the illustrated ones and the doorjamb rebate at this higher level (compare Figure Figure 108 with Figure 109).

### The entrance

The LHS guardcell opening is illustrated in Figure 109 in which the base of its entrance is shown clearly raised above the passage floor level. The stones in the entrance to the guardcell are, with the exception of the lowest one, loose, not keyed



**Figure 108** View of the entrance passage from inside the broch.

into the masonry and in all likelihood, structurally irrelevant to it. The left hand edge



of the ope virtually abuts the doorjamb and the latter is not keyed into the masonry of the guardcell entrance. The doorjamb is nonfunctional in its current relationship with the guardcell ope, not least because there is not space for the insertion of the receiver

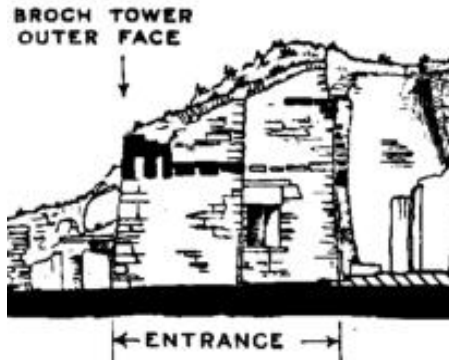


Figure 109 The LHS side elevation of the entrance passage (after Callander and Grant 1934)

of a locking bar. The bar-hole exists on the RHS of the passage but lies outside the doorjambs and is now relict and nonfunctional.

It is apparent from Figure 89 that the bar-hole, atypically, accesses the RHS guardcell. The rectangularity of the latter suggests that it is a secondary build into which the bar-hole was incorporated because it would have been impossible to restore the locking bar function in any other way. The opposite receiver is now lost or masked by replacement masonry. In the aggregate three phases are demonstrated here; the first was a standard RSM bar-hole and receiver, the second, the insertion of a new guardcell and bar-hole and the third the loss of the receiver hole and abandonment of this locking device. The 840 mm long passage giving access to the LHS Guardcell has a distinct building break about midway through its thickness, where the broch's LHS entrance passage wall abuts the structural wall of the guardcell (Figure 111). This wall has been modified by the addition of a wallface, presumably masking earlier features, like the receiver hole.

In other brochs where the bar hole accesses the guardcell the passage's masonry should be examined carefully for biographical evidence of the type described here for Midhowe.



**Figure 110** The short access passage to the LHS Guardcell. Note the building join in its right hand side wall.

The outer edge of the LHS of the broch entrance passage, the doorjamb with its ascending rebate and the inner edge of the passage sidewall are all truly planar masonry faces. Comparison of the inner edge with the Inner Lining Wall (ILW) illustrates the point that this linearity is incompatible with the fate of the Inner Wallface, as reflected in the vertical curvature of the abutting ILW (Figure 111).



**Figure 111** The ILW at the entrance passage (LHS) The deep concavity of the wall is indicated by the sweep of the masonry lines. The stumps of the original passage lintels are visible top left of the image where the innermost lintel, now lost may have lain in a scarcement at this level. It is probable that the broch wall was substantially rebuilt above this level.

It is clear, especially from the structural tomography, that the middle of the inner wallface in the northwest quadrant moved significantly outwards, i.e. away from the

centre of the broch. This formed a deeply concave wallface, and no doubt severely damaged the original masonry. This was remediated (if not remedied) by the insertion of a large panel of masonry, forming the ILW. However, this damage does not seem to have extended into the passage side walls, which, being orthogonal to the direction of movement, may have resisted deformation at its lower levels. The current configuration of the entrance passage subsumes the suite of features discussed above, which taken in the aggregate, strongly suggest that it was extensively rebuilt, as a broch entrance, at some stage. It is probable that this followed the distortion of broch wall that was ultimately to be the cause of the ILW build.

The three innermost lintels were probably smashed out of the lower lintel table then or later; tusks and voids suggest demolition rather than failure and may indicate the need to provide additional head room for access from the entrance as the broch interior filled up. A higher internal floor level would be consistent with the requirement for an elevated scarcement.

### **Supra Passage Void**

The differentiation of the passage lintels demonstrates the principle of strengthening the outermost for load bearing under the outer wall. The current Supra-Passage Cell (Figure 112) continues the vertical line of the passage sidewalls and it ends at the doorjamb rebate. At the outer end, the outer wallface runs over the massive first and



**Figure 112 The supra-entrance cell viewed from the upper lintel table; note tussing (on left) of a lost innermost upper lintel which had extended this lintel table to the line of the doorjamb.**

vertically set second and third lintels, the third lintel is visible in the photograph. Its side walls begin to corbel in over the lintels, to form the cell, which would have covered the three mid lintels and supported the mass of the core of the outer wall. Caution is required here because it is not clear how much of this arrangement was manufactured in conservation. It is unlikely that a conserving architect or mason would spuriously invent a chamber here and some comfort may be taken in the idea that the configuration has a basis in fact.

## Scarcements

An original scarcement is indicated by the details observed at the inner left hand side of the entrance passage (above). However, further evidence indicative of its erstwhile existence is lacking. A scarcement survives intermittently at some 3.3 m above the garth solum. This scarcement is missing from the area immediately anticlockwise from the entrance passage because the wall there has fallen out. The major loss of wall core and outer wall right of the entrance must therefore post-date the insertion of this upper scarcement. This is consistent with the observation (above) that the external buttressing was inserted to protect the H2 ó H4 structures from the continuing deterioration of the outer wall.

The Scarcement is not visible behind the ILW on the other side of the entrance and it is absent between the end of the ILW and the first level stairway ope. It reappears again clockwise of the stairway ope but there is enlarged by the addition of up to 5



**Figure 113 The surviving scarcement. Note that these montages distort distance and proportion.**

courses of corbels centred left of its junction with the stone packing on the septum filling the gap between it and the bottom of the scarcement (see bottom right in Figure 113). Thus, the scarcement is later than the stair ope, later than the formation of the aumbry and earlier than the local ILW. The corbelling on the scarcement had some function in common with the septum, and is thus, functionally coeval with the septum for a period, but the scarcement may predate the septum.

### The fallen wall

Anticlockwise from the entrance passage, in the southwest quadrant, the outer wall has fallen outwards and the distorted gallery is exposed. It is clear that both the inner and outer broch walls in this area have been displaced outwards and much of it has fallen away. The stones of the core of the outer wall, still densely packed and in correct relative positions to each other now rest at an angle of  $20^\circ$  to the horizontal, whilst those of the inner wall rest at c. $30^\circ$ . The inner wall's exposed core is built in an apparently random fashion (Figure 114) but maximisation of surface to surface contact has been locally sacrificed for horizontality of the bedding planes and



**Figure 114** The breach of the south wall. The apparently vertically set stones, like the one indicated, have their horizontal bedding-planes set in the horizontal building plane and their 30o/60o cleavage-planes in the vertical, the better to resist compressive forces.

apparently edge-set blocky stones may have been thus positioned so that the parallel bedding-plane faces are in the horizontal plane, thus the stone indicated in (Figure 114) has its  $60^\circ/30^\circ$  cleavage planes set vertically. This arrangement maximises the

stone's ability to resist compressive forces and the consistent placement of stones in this fashion indicates a conscious, rational appreciation of the best use of materials in the novel tower structure. Of course, this assumes that the exposed face is not a



modern confection, perhaps not an entirely safe assumption at Midhowe. On balance, it is probable that the Iron Age builders would have been more disciplined in their stone placement than the relatively modern work squads, and

**Figure 115 View along the exposed gallery foot in the south breach**

so the assumption is not entirely unreasonable.

Views along the current foot of the gallery exposed in the southern breach show that the Outer Wall's inner wallface (to the right in Figure 115), presumed originally vertical or even slightly inclined inwards, had been displaced outwards at an angle measured at c. 64° degrees to the horizontal. The outer wallface of the Inner Wall (left of centre on Figure 115) similarly 'beetles o'er its brow' by 54° degrees at this point.

The horizontal displacement of the inner wall measured a minimum of 640 mm outwards at a height of 870 mm, beyond which the upper parts of the wall sheared off and fell outside the monument, together with the greater part of the outer wall. These data represent the centre of the area of destruction. More generally, the upper surfaces of the stones within the Inner Wall slope down toward the outside at 30°; those of the Outer Wall slope at 20°.

Close to the west end of the breach, the ground gallery can be seen to tilt outwards, at an average of 25° (Figure 116). Thus, the gallery beside the breach survived being canted outwards through 25° degrees out of the vertical. Freshly broken stone can be observed in this gallery, as indeed within all the accessible gallery voids, which



**Figure 116 (left)** The West end of the breach in the outer wall. Note how the entrance masonry, visible top left, is horizontally set above the tilted masonry of the edges of the breach in the wall

suggests that the decomposition of the broch wall continues, albeit very slowly, see the discussion on masonry creep in Chapter 8.

The neatly stacked arrangement of stones within the gallery void near the top of Figure 117 is assumed to be an artefact of conservation. The stair steps formed near its top seem aligned on the upper gallery and are contained between the built wallfaces, not keyed in. They rise anticlockwise to the monument, uniquely in the broch *oeuvre*.



**Figure 117** View along gallery floor towards the south end of the outer wall breach

It is not possible to ascertain whether this stairway fragment is, if not original at least an authentic Iron Age development, or simply a modern introduction. It seems at least probable that these steps gave access to the wallhead when

the ground levels inside and outside the broch was at something like the level of the lowest step.

### **Towards a site biography**

The observable sequence of failures and repairs has been set out above. Built as a broch tower, the monument's ground gallery deformed under pressure from above, suggesting that this ground galleried broch incorporated some longer term instabilities at its initial build. The deformation involved the bulging inwards of the gallery sides on the ground floor and their slewing outwards with height. It is probable that some part of the upper levels of the broch were dislodged quite early in its biography. Similarly, given the fragility of entrance areas in general, it is probable that the primary entrance area was the focus of unresolved circumferential forces associated with the deformation under self-load and ultimately failed.

It was rebuilt, and at the same time the relining of the entrance passage and re-facing of the entrance façade were undertaken, requiring modifications to the guardcells and their entrances and the relocation of the bar-hole. The loss of the bar-hole receiver followed further rebuilding in the passage.

In addition, the stacked voids in the inner wall failed and parts of the inner wallface were lost into the garth. With the latter went the original scarcement which, in the RSM, would have been level with the inner end of the entrance passage corbels.

The galleries were shored up by the insertion of blocking deposits of edge-set slabs to prevent their further bulging into the gallery space. The entrance was remodeled and rebuilt from close to the current ground level. A load-bearing composite beam was reinserted at the outer wallface to carry a rebuilt outer wall and the lintel table was reestablished. If the ground floor scarcement was not reestablished at this time, the inner passage lintels may simply not have been replaced. Alternatively, they were replaced and then slapped out later, when the interior had begun to fill up with debris. The deepening of the contained deposits is indicated by the migration upwards of stairs, the aumbry and other internal features and ultimately, the second floor scarcement was inserted. The failed void access to the ground floor stair was



blocked off, and the upper voids of the 3 o'clock stacked void were blocked in and then covered over by the new Inner Lining Wall.

This first rebuild saw the reconstitution of a broch as a broch albeit that some features were masked, modified or omitted.

It is probable that the settlement of the broch wall continued until a catastrophic structural failure resulted in the loss of the outer wall and parts of the inner wall on the south side. The inner wall was apparently not breached and its backing masonry was reinstated, while the outer wall was not replaced. The debris from the collapse on this side may have remained in place, possibly even into the modern era because no secondary structures were inserted outwith the broch on this side. This indicates that the surrounding settlement was probably secondary to the original broch build. It is probably at this time also that the upper levels of the broch were further reduced, to something close to the surviving height.

Possibly abandoned for a time, settlement at the locus was resumed with the construction of the external houses and workshops, some of which were built over the defensive ditch, while the inner ditch was cut through tertiary debris from the broch (see 'Section West to East Facing North' in Figure 88). Within the broch, the height of the septum seems to suggest that the interior was kept free of debris or had been cleared out. However, the foot of the short flight of steps leading to the upper mural cell and the hearth stone on top of the cupboard-like structure together with the floor of the stair foot ope, are all on the same level and prompt the speculation that the interior had filled to this level when they were inserted and used. This level also corresponds fairly closely with a paved area on the outside of the broch (see the feature marked 'Paving' on the 'Section along inner ditch, facing South-West' in ). The slab built cubicle at the terminal of the septum just inside the entrance passage was found to have a hearth on its capstone, implying a related floor level c. 2 m above the current solum. Mackie's observation is well made:

'At Midhowe the arrangement of Levels is less clear-cut than in most other exposed brochs.' (MacKie 2002, 235)

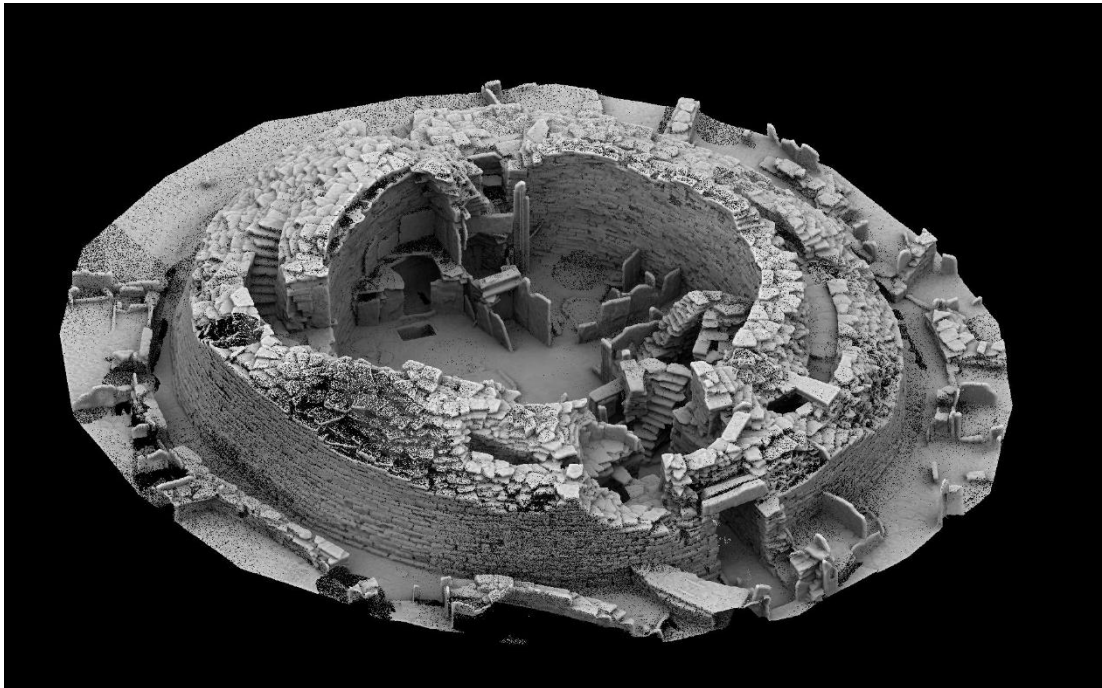
Cumulatively these indicate that by this late stage in the site development, the residents of the broch would have experienced the structure as an exceptionally thick-walled round house on a knoll, surrounded by other curvilinear houses. Access may have been maintained on one side of the septum, so that the broch entrance remained in use, but it is more likely that access was gained from the side of the knoll, possibly via the dilapidated southern side.

The aim of this summary is not to establish a definitive reading of the structural history, which would require further (planned) work, but simply to highlight the main elements this would have to encompass and to demonstrate that alternatives exist to the present rather simplistic biography. More importantly, the sum of the evidence supports the idea that the original broch was of RSM type, albeit built close to the edge of the buildable envelope in terms of the stone type used and its capacity to resist deformation under self load.

It will be clear that prior to the monuments excavation in the early 1930s, no living person had ever seen the monument as it now is. The monument now presented as a key exemplar of the broch tower is a chimera, a monstrosity compounded of different structural accommodations to at least two tectonic schemes, viz, broch as broch and broch as citadel within walled village and both as central places gradually being transmorphed by their own decomposition products.

## Gurness broch

### Background



**Figure 118** A laser scan image of the broch at Gurness.

The broch of Gurness (Figure 118) was excavated over a 10-year period, 1930 ó 1939. It was initially supervised by Craw, until his death in 1933, and thereafter under the general direction of Richardson with field direction successively by Balfour, Yeoman, Craig-Brown and Tulloch (Hedges 1987, 1-2). Craw cleared out the interior in less than a month and then by trial trenching established the need for further excavation around the monument. The three broch-encircling ditches were dug out and the intervening ramparts were revealed (Figure 119). The outer buildings were cleared and prepared for presentation, in part by the removal of some overlying structures to get to earlier ones. Abandoned for the duration of WWII, the monument finally underwent some conservation in advance of presentation. Richardson did not prepare a full excavation report, his RCAHMS inventory account and a guide pamphlet to the monument being his only contributions. The stated aims of the fieldwork were to clear the structures and collect relics and while the concept of stratification was understood, it was applied only in a very rudimentary fashion.

Hedges notes that conservation and preservation of structures was the driving force in all the fieldwork undertaken and annually, fieldwork was followed by consolidation and reconstruction initially by contractors and later by Ministry foremen and hands (ibid 2). This approach meant that all of the recorded plans and sections, which seem to have been accurately prepared, were designed to establish relative heights of structures for purposes of reconstruction and presentation (Figure 120 & Figure 120). Soft deposits were not recorded.

In 1987, John Hedges published an account of the monument based on the inadequate original records (Hedges 1987). Hedges focussed on the notes and letters of Craw (ibid 15-17), rather than the writings of Richardson, whilst MacKie has rather taken the opposite position (MacKie 2002; 227). That they come to different conclusions is not therefore surprising. However, these differences are instructive for their power to illuminate the difficulties that lie in the practice of excavation-for-presentation and for the power of a prevailing paradigm to frame observation by constraining the domain of evidence issues which affect both Hedges and MacKie, and are discussed in Chapter 8.

Craw identified four main periods, to which Hedges added a fifth to encompass Viking burials on the wallhead level (Hedges 1987 15-17), thus:

- i) Period A comprises the Broch Tower.
- ii) The buildings in and around the tower are attributed to Period B
- iii) An internal stairway overlies rubble and therefore postdates some episode of collapse of the tower. It is attributed to Period C to which cellular buildings outwith the monument are also attributed.
- iv) Wallhead material indicative of settlement after the collapse of the broch tower was attributed to Period D, as are sub-turf features elsewhere on the site
- v) A Viking burial was inserted in the top of the mound after Period D

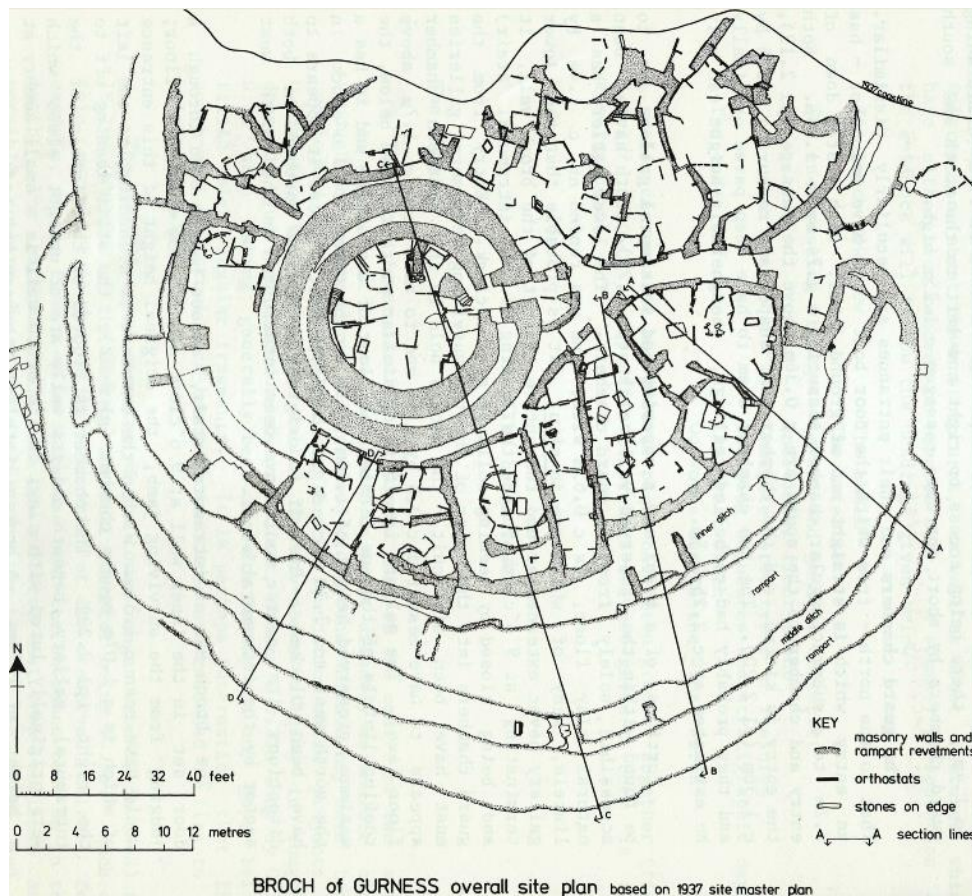


Figure 119 Ground plan of the Gurness site (after Hedges 1987, Fig 2.1)

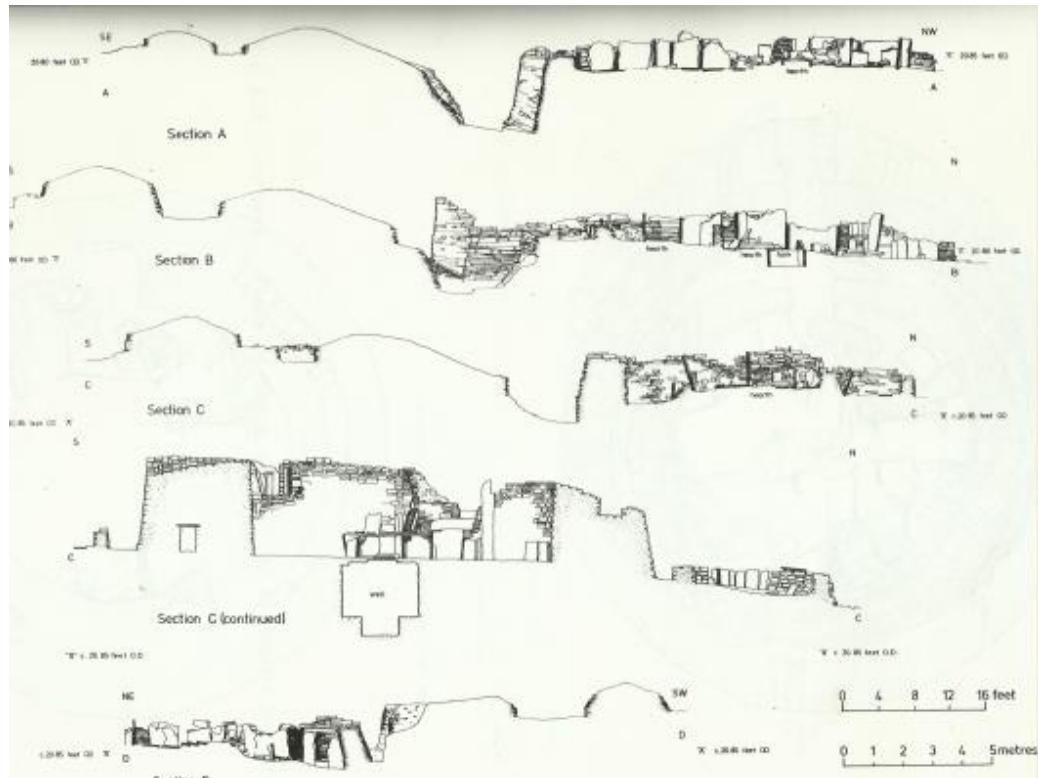
Mackie, following Richardson's phasing suggests the following:

i) Phase 1 Building of the broch and its stone outer wall, three ditches and intervening ramparts.

ii) Phase 2 Broch collapsed with basal gallery crushed inwards by weight of the broch tower. Following clearance of fallen materials many small buildings were erected around the broch, between it and the outer village wall, the latter having also fallen and been rebuilt further out into the first ditch. Secondary slab-built partitions were inserted in the garth with hearths and tanks on one or more new floor levels.

iii) Phase 3 All earlier structures being now ruinous, a new surface established itself on the debris and late buildings erected on that; including one that

presents as a LBA courtyard house of Jarlshof type, and one that is a later, Viking longhouse.



**Figure 120 Gurness site profiles (after Hedges 1987, Fig 2.2)**

Mackie notes that the artefact assemblage ÷ have to be regarded now as largely unstratified.ø(MacKie 2002, 230). The assemblage includes what is definitively and diagnostically Late-, or Post-, Iron Age material some of which MacKie (ibid) attributes to the 7<sup>th</sup> and 8<sup>th</sup> centuries AD. Whilst this is probably correct, it is not possible to rely on it as an index of the age of the broch because it must be acknowledged that with few exceptions, the artefacts are so chronologically insensitive that they do not assist us in understanding the remains of the broch.

As Table 6.1 illustrates the differences between these writers seem merely to be matters of where the boundaries between periods and phases are placed and there is little substantive difference in fact, not least because the ages of the boundaries remain unknown.

**Table 6.1: Hedges and Mackie: Gurness Chronology**

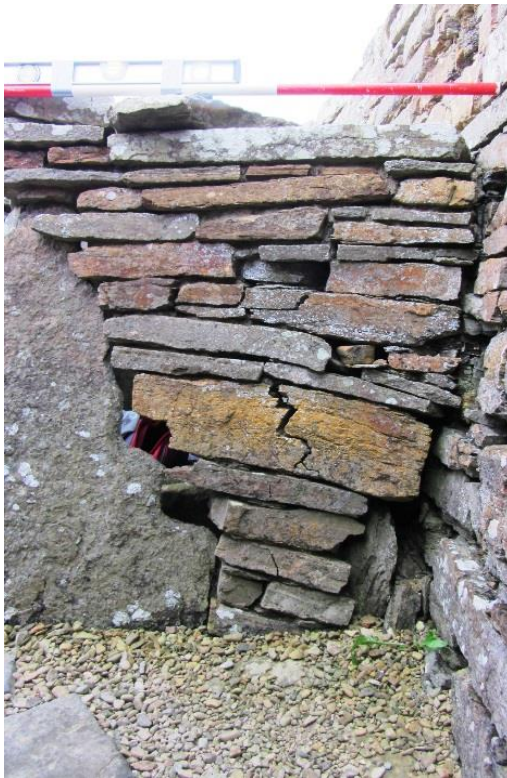
Event	Craw cited by Hedges	Hedges 1987	Mackie 2002
Broch Construction	Period A	Broch Period	Phase 1
Surrounding defences			Phase 2
Broch Collapse			
Internal structures	Period B		
External Structures			
Internal Stair,	Period C		
Cellular Buildings			
Final settlement on wallhead	Period D	Post-Broch Period	Phase 3
Viking longhouse and burials	Innominate late period	Viking Burial Period	

The focus of this analysis lies in the information observable in the surviving broch remains and its implication for episodes of construction and destruction of the broch tower under the forces of nature or humanity. Therefore, the following account describes the broch and those of its features relevant to this discussion.

### **Broch metrics and levels relative to the current solum**

The broch stands on a platform within the inner ditch. MacKie measured its outer diameter as 19.2 m and its inner as 10.07 m. Hedges notes that the tower was built over a single-stone plinth course (projecting 150 mm) resting on boulder clay. Its masonry comprises stone slabs 250 mm long by 100-200 mm high in the built face and he notes that the external face on the southwest was fire reddened to a height of

1.5 m. The tower's external diameters (per Hedges) ranged from 17.5 m (N-S) to 18.25 m (WNW-ESE) and its internal diameters averaged 10.3 m. The wall was c. 4 m thick at the entrance but only c. 3m in the north. The height of the surviving outer wallface above its local solum lies in the range 1.05 m (N) to 2.5 m (S) while the internal wallface ranges from 2.5 m (N) to 3.6 (SE).



**Figure 121 (above) Earthfast (orthostatic) slab anticlockwise from the entrance with masonry infill between its notched edge and the brochs Inner Wall (IW). Note separation of the masonry from both the matching notches in the orthostat and the IW. The ranging rod is horizontal.**

Hedges also suggests that there is an internal as well as an external batter but this is probably not correct. Notches were cut into the edge of an orthostatic stone slab set radial to the internal wall, at floor level, just anticlockwise from the entrance (Figure 121). These notches accepted the ends of stones in a masonry block built to fill the gap between the slab's edge and the brochs Inner Wall (Figure 121). It is clear that the IW has moved outwards sufficiently to disengage the ends of the stones from the notches in the slab and while the masonry infill has tipped towards the IW nonetheless a gap has opened between them (Figure 121). It is clear that the outer wall sagged outwards after this arrangement had been put in place in a secondary reuse of the interior. It is assumed that the horizontality of the uppermost courses is an artefact of modern conservation, implying that the IW is still moving outwards.



## The entrance passage

Paved throughout its 4.38 m length, the entrance passage lies on the east side of the monument. It is lintelled at 1.7 m above the floor, with massive stones some, or perhaps all of which have been put back into position (per Hedges). There probably was a chamber over the door but the surviving arrangement may have been ðconservedð There is an inward-opening door fitting midway along the passage with doorjambs, sill stone, pivot stone, bar hole and receiver. The outer passage is 1.18 m wide, the inner passage is trapezoidal being 1.7 m wide just inside the jambstones, reducing to 1.4 m at the inner end<sup>143</sup>. The doorjambs, or ðchecksð are 2.42 m from the outer end and have a gap of 1.2 m between them.

There are two guardcells leading off the entrance passage and each in turn leads to the ground gallery. Again, the differences between the Hedges and MacKie accounts are trivial with two exceptions; MacKie suggests the guardcells were lintelled and not corbelled, and Hedges implies that their entrance lintels were re-erected following excavation.

The chamber over the lintels seems to have been an original feature and is visible in a photograph of 1930 or 1931 (see Hedges 1987, Plate 2.6, page 5), in which the inner lintels appear to have been horizontally laid slabs. Currently an innermost, edge-set, lintel has been added to the passage, an artefact of conservation.

In Figure 122, the inner right hand end of the passage is illustrated. The inner edge of the passage does lean outwards, but not as much as this photomontage suggests. The inner wall (IW) is clearly visible above the lintel of the guardcell entrance, as is the infilling of the gallery, over which a simple and very late cell has been constructed. The mean angle of inclination of the IW ( in Figure 122) is, by onsite measurement, approximately 9.46° out of vertical but at the entrance, is up to 15.6° out of the vertical. It is concluded that in the area of the entrance the inner wall tilted outwards

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<sup>143</sup> MacKie essentially confirms this description with minor metrical variations: length 4.47 m, width 1.14 m at outer end, 1.73 m past checks and 1.42 m inner end.



**Figure 122** The photographic panorama of the entrance area of the broch (left) exaggerates some of its proportions, but the laser scan (right) is metrically precise.

through an angle sufficiently large to be incompatible with structural stability in a tower. The deformation of the guardcell entrance opening and the accommodations of the masonry above it, including blocking of the gallery and re-facing of the IW point to a history of adaptation following the collapse of the tower.

Within the broch wall, anticlockwise of the entrance and entered from the guardcell, a gallery can be seen curving away, within the wall's thickness, with an apparent additional but very low gallery above it (Figure 123). Both Hedges and MacKie seem to interpret the superimposed voids as separate galleries, albeit that the upper gallery is only 500 mm to 600 mm high. Viewed from above, the line of the upper gallery runs from the back of the guardcell, anticlockwise to the blocked high level cell (below) at about 1 o'clock. Over the first half of that circuit, the sides of the gallery enclose a paving of slabs, overlying beds of horizontally placed slabs (Figure 123 & ).

Beneath this slab-on-slab foundation for the current surface paving, cruder structural lintels can be seen, under debris. These lintels are embedded in the gallery walls and once formed the roof of the ground gallery (Figure 123). They are now crushed, broken and displaced, presumably by the forces that deformed the lower broch wall throughout.

The gallery walls are clearly visible beyond the 1 o'clock, high level cell and there the gallery is choked with slabs (Figure 127) lying in the disposition characteristic of a fallen wall, as demonstrated by the writer's experimental work at Spittal, in



**Figure 125 (left) Entrance from the RHS Guardcell to the ground gallery and an overlying void apparently interpreted as a gallery by both Hedges and MacKie.**



**Figure 124 Slab-on-slab secondary paving inserted between gallery walls.**



**Figure 123 (above) Original roof lintels of the ground gallery, many broken and displaced, under levelling deposit of slabs and upper slab pavement (on far right).**

Caithness (Figure 126). They have fallen from the outer wallhead into this gallery space and have not been disturbed thereafter, possibly because the outward bulge of the inner wall has trapped them in place (Figure 127).



**Figure 127 (left) Gallery void south of the high wall cell with slabs fallen from the RHS now pinned under the outward bulge of the inner wallface.**

**Figure 126 (right) Cascade of corbel slabs experimentally built and forced into failure at Spittal Quarry experimental centre 2006**



The interpretation of these observations offered here is that Gurness underwent a catastrophic structural failure with loss of fabric from above, and distortion below the level of the current wallhead. When the wallhead was reformed, clockwise of this position, the broch no longer functioned as a broch and was reused as a two storey citadel. Thus, we can assert that this collapse ended the period of the original broch tectonics. Whilst generally unhelpful, the artefact assemblages are not inconsistent with a major phase of reuse perhaps, and tentatively, from around second century BC to second century AD, and followed by probably intermittent re use well into the early medieval period. A construction date before 200 BC is indicated.

Anticlockwise of the entrance, the inner wallface of the ground gallery was compressed inwards and the gallery as a structural entity was slewed outwards and reduced in height. Thereafter, the gallery void above its erstwhile roofing level was infilled with rubble over which layers of stone slabbing were covered with neatly laid slabs, some of which have survived. Further south, the gallery was infilled with collapse debris and abandoned, probably because its remains were too unstable to contemplate emptying and reforming it. This implies that the repair and reuse of the monument lay outside the limitations of the broch tectonics, and belongs with the secondary, but still Iron Age, reuse of the monument.



**Figure 129 a, b and c** The anticlockwise end of the LHS ground gallery at its blocking at 9 o'clock (a). Here its roof lintels are intact (b) but closer to the guardcell, the roofing lintels have failed and chaotic structural debris has bridged the gap (c)

The damage to the LHS guardcell may have been equally traumatic but the ground gallery on that side has survived in relatively good condition. The LHS guardcell is unroofed and is likely to have failed, given the collapse of the RHS wall. The ground gallery roofing has similarly suffered in the area of the guardcell, but it is relatively intact further along.



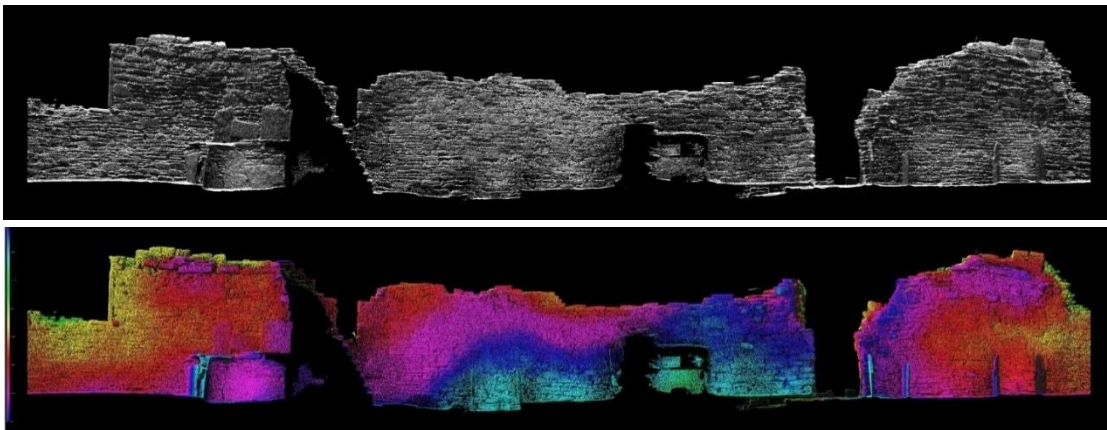
**Figure 128 (left):** The profile of the Inner Wallface adjacent to and below the 1 o'clock high cell. The ranging rod is vertical.

Both Hedges and Mackie refer to the end wall of the LHS ground gallery as if it were some secondary or adventitious blocking, but it is keyed into the gallery sidewalls (see Figure 128a). It is interpreted here as the rear of the masonry block that contained the stairfoot cell and adjacent stairway from the ground to the first floor. This would place the stair entrance at ground level under the 1 o'clock high cell, and explain the modified remains of that sub-assembly as the first floor void of the stacked void we should expect over either the stair entrance or at the stair landing, per the RSM. In this instance the

interpretation of the gallery and its sub-assemblies in terms of a canonical RSM broch resolves the nature of another sub-assembly which it is argued here is confirmatory of the RSM.

Happily, this matter can be tested to resolution by future excavation of the wall structure in the area. Given that the walls continue to move at this broch, it is not impossible that an opportunity may arise to examine their structures more closely following a further collapse. The wallface below the high cell slopes outwards quite significantly (Figure 129) and had several rispain joints within it, each interpretable as a building break, but it is largely obscured by the internal circumferential stair. Taken in the round, these observations may not constitute proof that an entrance to a stairway once existed here but they are consistent with this interpretation, which they do not refute.

### The aftermath



**Figure 130** Laser scan data for the inner wallface, projected onto a right cylindrical surface and then 'un-wrapped', In the lower image, the colour codes measure the distance of the areas of wallface from the central axis of the right cylinder, based on the key on the left, in the order green, blue, pink, orange and red (near to far).

It is clear from Figure 130 that the inner wall leans outward significantly all around its circuit. The green section (centre of the image) seems to record a minimum of disturbance and indeed to project slightly into the garth. The intermural stair, just left of this part of the wall, beyond the point of major constriction of the ground gallery,

has been lost and probably infilled when the original stair access was lost. The wavy colours in the midsection indicate warping in the cylindrical form of the wall.

Overall, the scale of distortion of the broch wall is not compatible with the survival of a tall tower. It is clear that the upper storeys of the structure fell down and were perhaps then taken further down to apparently stable levels that varied across the broch. The greatest dislocation occurred in the northern half of the broch wall circuit. Its height was probably reduced to the top of the entrance passage and rose from there towards the 12 o'clock position. One cannot know how high the greatest surviving height was, but the asymmetrical survival of brochs is a commonplace; see for examples, the Glen Elg brochs, Dun Carloway and Dun Dornaigil.

The use of asymmetrical forms is inconsistent with the tectonics of the RSM broch and probably incompatible with the continued use of a wooden mezzanine structure in the garth above ground level. Such reuse must be interpreted as secondary and non-broch in character.

The renewal of the floor in the upper gallery suggests that the sidewalls and possibly even the roof of this gallery were substantively intact or could be brought to completion from the ruins remaining. Otherwise it is hard to see why this refurbishment took place as the provision of a wall-walk could have been achieved at significantly less cost in effort and time.

In the immediate aftermath;

- i) the interior of the broch was probably emptied of debris (but recall that the current solum is not the primary old ground surface OGS)
- ii) the floor of the second level gallery was re-established some 600 mm or so above the ruins of the original
- iii) The first-to-second floor stairway was truncated to match with the new floor level, which in fact it oversails somewhat.
- iv) The ground/first floor access to the stairway was sealed off and a new, circumferential stair was built beside it, giving access to the re-established gallery floor. Its upper end was extended to establish contact with the

high scarcement anticlockwise of it. Thus could have accessed a floor level established on the scarcement.

- v) Substantial parts of the broch's upper storeys may have survived in the southern half of its circuit.

It is probable that the earliest of the internal fittings were inserted at this time and equally probable that the level of their insertion was at or close to the original broch OGS. There are indications of an original scarcement at the inner RHS corner of the entrance passage, where a single stone protrudes beyond the wallface. A similar single stone protrudes from the wallface at the foot of the right hand doorjamb of the first floor stairway ope (the 9 o'clock ope), with a further stone a little distance clockwise of it. It is suggested here that the original scarcement was removed, following the initial structural failure.

Hedges noted that three fragments of scarcement survive in the SE, SW and NW, of which the first two are 3.45 m above the current garth floor, and the third is 2.9 m, *contra* Mackie who cites the single measure of 3.67 m odø. It is clear that they are set at different levels. MacKie has also noted that the interior cubicles made of slabs and some masonry piers, were erected on top of a layer some 460 mm to 530 mm high above the lower, probably the original, floor. This would place the putative scarcement levels in the region of 4 m above the garth level. In addition, the scarcements in more complete brochs are consonant with other structural features, typically the innermost entrance lintel and lintels in stacked void features, whereas these pseudo scarcement fragments at Gurness are not consonant with any other broch features.

It is argued here that an original scarcement set some 2.3 or 2.4 m above the original garth floor was removed following the initial collapse which may in any event have damaged it beyond reuse. The overhanging wallheads, hitherto referred to as scarcements are in fact arrangements for structures built within the broch at a much higher internal level. These various accommodations to the dilapidated state of the broch were in essence designed to restore the broch as a broch, but with a ground floor raised by one storey.



It is possible that this was the only catastrophic failure of the broch structure but the likelihood is that further down-taking of the wall would reveal that there were several episodes of dilapidation until the tower was reduced all round to something a little higher than what now survives. It is at this stage that the reduced broch was given a barbican-type extension to its entrance arrangements and surrounded by the complex of simpler houses but it is of course important to note that the reduced broch was still the central focus of the surrounding structures of the broch village<sup>144</sup>. Only new excavations could unravel the chronological complexity of the monument's biography, but sufficient indications survive to suggest that even after the catastrophic changes described above, its fate was not a simple one.

### Later use

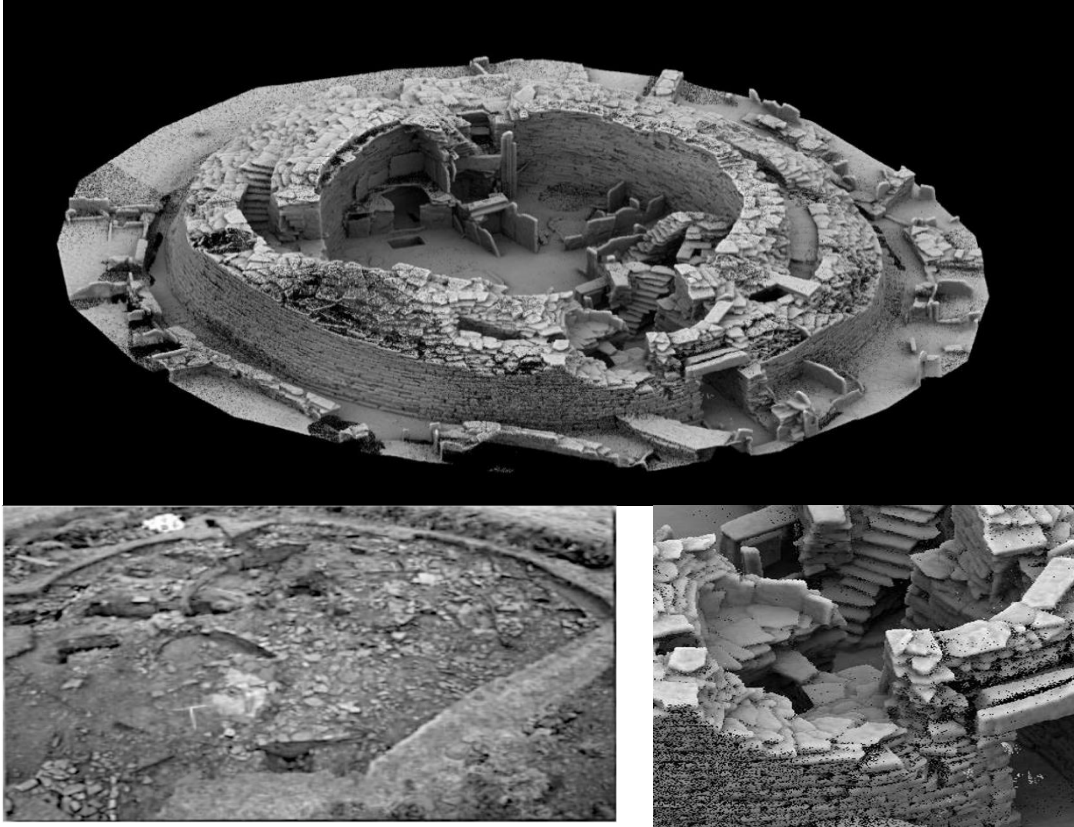
Figure 131 shows part of a cell structure preserved in the masonry of the wallhead above and left of the entrance. Its form is impacted upon by the modern wall built over the concrete lintel of the restored entrance passage. The part which is lined with upright slabs is also truncated by the ground gallery and was no doubt dug out in the emptying of the monument, as was the rest of the structure which extended beyond the broch wall.

The surviving elements indicate that this was a cellular house (*sensu* (Gilmour 2002a, Gilmour 2005, Henderson 2007, 164-5). MacKie had earlier noted this feature at Gurness (MacKie 2002, 232), commenting that its existence confirms that the broch had been reduced to this level when the cell was built. Henderson notes five other sites at which cellular forms may postdate the eponymous monument, albeit that these were not observed by their excavators (Henderson 2007, 164), and Harding suggests that some excavators have failed to identify the true nature of edge-set slabs on the sites of Ardifuar, Dun Mor Vaul and Rahoy (Harding 2004, 272-3). No doubt other examples of missed, or mis-identifications exist.

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<sup>144</sup> For a useful access-analysis of the structures built around brochs, see Foster, S M (1989). "Analysis of spatial patterns in buildings: access analysis as an insight into social structure" examples from the Scottish Atlantic Iron Age." *Antiquity*; Vol. 63(March): 40-50.

Excavations now underway at The Cairns, on South Ronaldsay (Figure 131) reveal a palimpsest of cellular, and later, house fragments that extend over the mound formed around the fallen broch<sup>145</sup>.



**Figure 131** The end-cell of a cellular structure can be seen above and left of the entrance lintel, cut into the wallhead (upper image). The in situ side slabs of the cell can be seen (bottom right) and the scar left in the broch masonry by its adjacent LHS side cell. In the bottom left frame, Excavations at ‘The Cairns, South Ronaldsay, Orkney, revealed cellular and circular buildings in the foreground, overlying the infilled remains of a broch (bottom left) thought to be 4th century AD. The rectilinear house forms (top right) are Norse and date to the 12th century (this image © Martin Carruthers, UHI).

MacKie refers to the wallhead remains in question as the foundations of a small circular chamber (MacKie 2002, 229) which, he suggests was inserted on the

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<sup>145</sup> The writer is grateful to its excavator (Martin Carruthers of UHI) for permission to include here an illustration of the monument under excavation (Figure 131 bottom left).

wallhead after the latter had been reduced to about its current height. In discussion, he suggests (ibid, 232) that the wall had been pulled down by the time the cell was built, indicating that human choice had been involved in the process, rather than the progressive combination of anthropic and natural decomposition favoured here. But, either eventuality would have marked the end of the broch tectonics and their substitution with something else.

## Structural tomography

The methodology for structural tomography, which was developed for this thesis, is described in Chapter 4, and has been applied to the point-cloud data from Gurness. An avi-visualisation shows the inner wallface apparently peeling away from the circle of best fit of the wallfoot as the plane of inspection rises (see CD s1164769, Midhowe AVI). It moves least adjacent to the entrance area and diametrically opposite it. It changes most and most rapidly at right angles to that direction.

This is consistent with the failure of the broch in the entrance area, possibly by simple collapse, and the outward collapse of the wall fabric at right angles to the entrance axis. The evident and highly variable outward inclination of the inner wallface at Midhowe has been identified by MacKie (ibid, 234) but rationalised in these terms:

As is usual in brochs the outer face shows a marked batter í while the inner is more vertical except in the south-east, where it seems to have sagged outwardsí (MacKie 2002, 234)

And, consistent with this somewhat dismissive view, he does not refer to the even more dramatic outward lean of the Gurness inner wallface (see for example Figure 130, above). Nonetheless, Mackie accepts Richardson's view that the broch experienced a partial collapse which was followed by refurbishment and reuse (Richardson 1948). Unlike Richardson, MacKie does not believe that any appreciable interval separated the events, basing his belief on relationships between structures external to the broch and the defensive ditches and their supposed relationships with the broch structure.

## **On canonicity and mutability at Gurness**

Hedges and MacKie agree that Gurness was a broch tower, although they agree on little else, and neither of them have really addressed the complex sequence of construction and destruction cycles for which evidence survives in the masonry itself. Both, and most of the several other commentators have based their discussions on dating the monument and its parts by means of uncontexted artefact assemblages that are incapable of supplying the resolution the task requires.

Nothing in the available evidence precludes the construction of the broch as an RSM broch, albeit one of particularly massive proportions. It is highly probable that it failed, either under self-load, or being close to its self-load limits of stability, under other applied loads, including wind loading. There is no doubt that this happened in the Iron Age because an Early Medieval cellular structure was built over the mound containing the reduced broch.

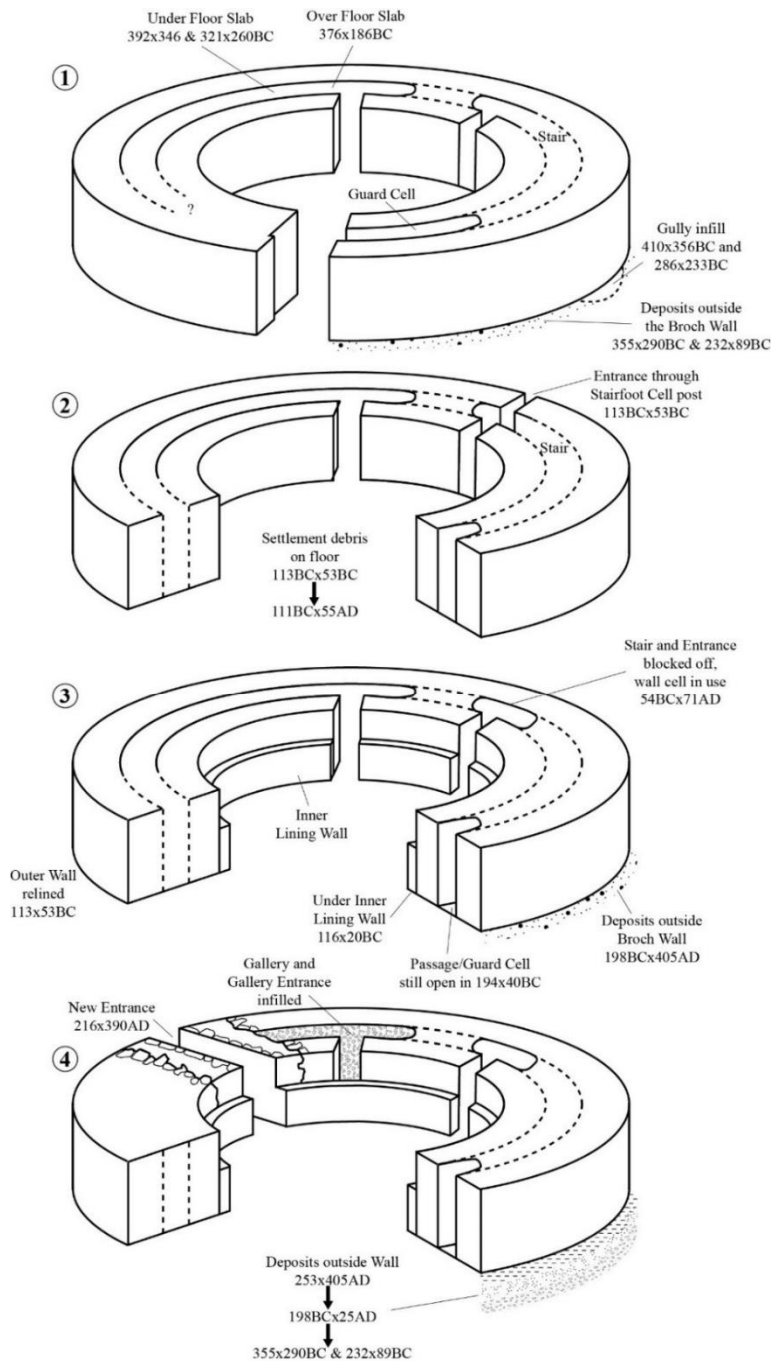
There is overwhelming support for the notion that the broch began its existence as a canonical RSM, most likely as a standalone structure and that the village was a secondary introduction to the site. Following a large scale collapse, it was repaired as a broch but its structural failure continued and eventually it became subsumed within its own decomposition products. Finally, reduced to a mound of settlement debris, the associated small cellular structures of the persisting village eventually began to be built above its walls. By this time, its tectonics, its specific relationships between people and built form, had been forgotten and respect for its existence as a broch had passed.

## **Thrumster Broch**

This broch was excavated under the direction of the writer in 2011 and its report is appended (Appendix Thrumster)<sup>146</sup>. The excavation revealed a complex history of change and reuse in the vestigial remains of what had appeared to be a very simple

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<sup>146</sup> This has been accepted for publication by Willis Publishing, in a two volume set alongside the report on Nybster Broch, with a putative publication date in 2017.



**Figure 132 The development succession at Thrumster broch, Caithness.**

solid based monument <sup>147</sup>. The observed pattern of structural alterations is represented in Figure 132, in simplified form. This indicates that the broch was built,

<sup>147</sup> In the following discussion, the architectural reader should be aware that radiocarbon dating for this period is only occasionally more precise than guesswork, or dating by artefacts, which in Scotland is broadly guesswork in almost all periods.

probably as an RSM structure, with presumably standard entrance features, a stairway at the 2 o'clock position and a length of ground gallery that was entered at the 11 o'clock position (Figure 132, 1). Guardcells may have existed but were not observed. No inner lining wall was present. A hiatus in settlement followed, during which soil deposits had formed in the interior and undergone some geochemical processes. No anthropic materials were contained in this soil profile which took more than decades and probably less than a century to form. Then, and presumably after the original entrance had failed or become compromised, a new entrance was fashioned through the stairfoot gallery (Figure 132, 2) and the broch was reused, this time for domestic settlement. Soil deposits containing anthropic material formed in the interior and outwith the broch during this period of use. Towards the end of this period, the external access was closed off, presumably a new door, the third, was fashioned or the original was repaired/rebuilt (Figure 132, 3). The inner lining wall (ILW) was erected in Phase 2 or 3, sealing beneath it areas of the sterile soils of the primary use. In Phase 3 or 4, the gallery access was closed off and the ILW, a diachronic structure, was built across its erstwhile position. Finally, an entrance, its sidewalls and abutments, not of broch type was slapped through the 9 o'clock position. Georgian and Victorian landscaping had removed all of the higher deposits within and surrounding the broch and only traces of activity associated with this entrance were found outside the broch (Figure 132, 4).

The first hiatus at Thrumster is paralleled at the broch of Borwick, Yesnaby. Watt's account of this monument describes a possibly original and apparently sterile floor lying under a deposit of small slabs into which some structural walls were built and over all of which a 600mm deposit of 'unctuous matter' was found; only the latter containing artefacts (Watt 1882; and see MacKie 2002 217 for confirmation of this interpretation of Watt). The many hearths discovered in the deepening deposit on the floor of Dun Telve, for example, most probably were formed during this first hiatus when squatting or informal use of the structural spaces took place. Two hiatus episodes are also well known from the Rhiroy semi broch (MacKie 2007a, 797: Periods III and V in his Figure 7.370). At Dun Bharabhat, the notionally primary

deposits were overlain with wall collapse<sup>148</sup> and overlapping this was a secondary settlement deposit. A deposit of soil had formed over the destruction layer and below the final collapse of the broch (MacKie 2007b, 1078 and 1081). A similar but later hiatus was noted at Beirgh in a peaty deposit that formed over the infilling of the garth at about the level of the scarcement, over which in turn the first cellular house was constructed (Harding and Gilmour 2000).

Radiocarbon dating does not rule out the possibility that the broch was built in the fourth or third century BC and abandoned with no detectable anthropic inclusions and no post setting for an internal wooden structure. An hiatus followed that may have lasted a century or more. Settlement followed that in the second and first centuries BC and possibly in the first century AD. This was followed by abandonment after which the fourth and final entrance was constructed for a period of reuse that began, probably not earlier than the fourth century AD. Its duration and the likelihood of even later reuse have all been lost to landscaping and gardening in the last three centuries.

However, radiocarbon would not rule out a much shorter period overall, perhaps confined to the fourth century BC. This is close enough to the MacKie schema to pass for it, and as proposed by Dr Derek Hamilton, in the appended report, is not refuted by the evidence provided we accept that the early dates should be written off as representative of earlier settlement or use of the knoll, for which no physical evidence has survived or was recovered. Both Hamilton and Barber versions of the chronological interpretation have been included in the report (Appendix Thrumster), and readers can form their own judgement.

The surviving remains at Thrumster are in general less than 1m high but it is concluded that this was originally a broch tower, on the balance of probabilities. It

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<sup>148</sup> Given that charcoal from the collapse dated to 250 BC x 10 AD it is a little unkind of Euan MacKie to suggest (ibid) that Armitø's argument for placing the monument's construction earlier than this span is indicative of Armitø's desire to push the construction of brochs earlier than his (Euan's) model (which approximates closely to SM2012), rather than a dispassionate reading of the evidence.

was built containing a stair and counter stair cell, and therefore was more than a single storey high. It contains the hollow wall and gallery entrance typical of broch towers. The masonry in the abutments of the final entrance give evidence of a crack swarm, implying that their superincumbent load even at this final stage, was sufficiently heavy to overload the surviving stone and create the cascade of cracking observed elsewhere (see Chapter 8, Resistance of stone to static and dynamic forces). The absence of large volumes of stone from the decomposed broch is readily explained by the clearance of the site, for which historical evidence exists, to form a garden feature and to 'clean up' the knoll as a feature within the designed landscape. Hence, on the balance of probability Thrumster was a broch tower and remained a tall structure until its final decomposition.



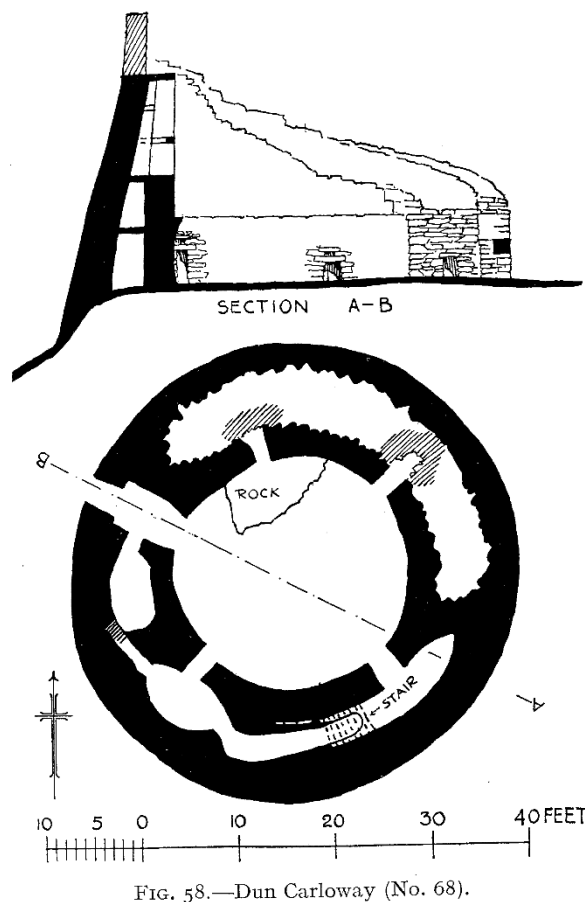


## Chapter 7 Case Studies Part 2 western monuments and global summary

### Dun Carloway broch

#### Background

The broch at Dun Carloway is a typical Western Isles broch standing alone, without attendant structures and sited on a steep rocky pinnacle, the shoulder of which is somewhat overlapped by the western circuit of the broch's outer wall. Its overall form and the forms of its substructures are close to RSM expectations, albeit that some modifications have taken place. Dun Carloway, at a little over 9 m tall



survives above four galleries in height<sup>149</sup>.

Figure 133 Dun Carloway plan and Section (RCAHMS 1928, 19).

The RCAHMS Inventory suggests that the outer wall is bonded to the inner wall by the lintel slabs of the gallery floors. Armit, echoes this belief,

øThese bridging slabs tied the walls togetherí ø

(Armit 1996, 109)

Direct observation suggests that virtually none of these slabs runs

<sup>149</sup> Whilst this has been accepted as its original height (Miers, M (2008). *The western seaboard : an illustrated architectural guide*. [Edinburgh], Rutland Press.) the evidence for this conclusion is not compelling. Similarly, Miers's suggestion that 19<sup>th</sup> century observers witnessed the broch compete and roofed with a large stone is probably an honest expression of a local tradition but is unlikely to prove reliable.

more than about 100 mm into the sidewalls and many are even more precariously set. Whatever the builders' intent, the slabs are better designed to prop the walls apart than to key them together.

The RCAHMS Inventory (RCAHMS 1928, monument 68) suggests that the massive outer lintel is still *in situ*, but the left hand side of the entrance [looking in] gives every indication of having been rebuilt. The right-hand side has a single bulbous guardcell which the Inventory survey (reproduced here in Figure 133, lower) shows was probably connected to the 3 o'clock cell at one time. That access is now blocked off by a mortared wall<sup>150</sup>.

2a



2b



**Figure 134** Inner wallface elevation panorama (2a) with detail of possible cell entrance at the 7-8 o'clock position (2b).

At the time the Inventory report was compiled, the entrance to the 9 o'clock cell was blocked with rubble and another area of rubble on the north of the garth, above the exposed bedrock, was believed to house an additional entrance (Figure 134). The

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<sup>150</sup> Tabraham was probably unwise to assert that the connection had never existed (Tabraham, C (1976-7). "Excavations at Dun Carloway broch, Isle of Lewis." *Proc Soc Antiq Scot* **108**: 156-167 & Plate 157.). Although unstated, the Inventory text invites comparison of this feature with the 5 m tailø running from the 3 o'clock cell anticlockwise under the stairway. The latter is referred to as the crawlwayøbelow.

inventory plan suggests both of these entrances accessing a single gallery. The 9 o'clock cell and its entrance have now been exposed and the cell interior has been excavated (Tabraham 1977) but no entrance to the northwards limb of the chamber has been discovered. The low level wallface is illustrated in Figure 134, and just right of the high point of the bedrock outcrop, the masonry between the two arrows does suggest that an erstwhile opening has been sealed off<sup>151</sup>.

Almost opposite the broch entrance, at roughly 12 o'clock, another cell entrance opens to a small cell on the left (a stairfoot cell) and the stairway to the right. The inventory account illustrates, a small relieving structure over the 12 o'clock ope. Field examination of the other opes indicates the possibility that these also had relieving structures (Figure 135), now obscured by modern conservation<sup>152</sup>. The inventory suggests that three lintels define two voids over the 12 o'clock cell but the upper void was infilled even then (RCAHMS 1928, 19 and Figure 56).

### **Broch Anatomy: Metrics and levels**

The inventory description suggests that Dun Carloway broch is built from stones averaging 460 mm by 150 mm (ibid 19). Measurement of 30 stones in the outer wallface randomly selected from those within armø reach at ground level indicates an average length of 777 mm by 250 mm. This average lies within a smooth range of from 510 to 1050 mm long; i.e. the size distribution is not normal and so no indication of a desired -standard stoneø can be discerned from it. The Inventory cites an external wall batter of -33 ins in 10 ftø (105.38° to the external horizontal or c 16° out of the vertical) which has been confirmed by direct measurement. The batter was measured at 2 m intervals clockwise from the entrance yields a mean batter angle of 105° in a range from 97° to 114° i.e. 15° out of vertical. The variations are significant

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<sup>151</sup> The RCAHMS drawing indicates that an opening did exist over the bedrock exposure and the RCAHMS surveyors are unlikely to have been in error.

<sup>152</sup> Without the illustration and description from the RCAHMS Inventory (their Figure 56) the claim that all of the gallery opes have relieving structures above them would seem hard to substantiate, and yet the evidence exists in plain sight.

for their coincidence with areas of the outer wallface that are not coplanar with the general curve of the wall.



**Figure 135 (above)** Sealed voids of relieving structures over cell entrances: the blue rectangles mark the void locations in the thumbnails above the main images.

**Figure 136 (right)** Extract from the RCAHMS 1928 record (their pPlate 50) of which the 2015 view is central above.



### **The broch wall**

The inventory identifies surviving arcs of four gallery floors, the third of which is gapped (Figure 137a). The fourth level, as represented in the Inventory cross section (here Figure 133), lies between the struts



**Figure 137 a (far left) The broken and displaced lintels of the third level. Their displacement and the buckling visible in 137 b (left) confirms that the intramural void is now narrower than it originally was. These indications suggest that the outer wall has also slipped downwards and inwards and moved slightly, anti-clockwise relative to the inner wall.**

of the stacked void. The lintels of the third level are skewed, not radially set and some wider gaps in the level indicate the probable loss of some lintels. In the area of the stacked void, the lintels are buckled and some have snapped in a pattern indicating a downward pressure on the outer side. Earlier writers suggest or assume that the abrupt constriction of the intramural void above the second level was a design feature. The inner wallface of the outer wall would in the RSM be expected to begin gently corbelling in over the intramural void at this height. However, it has been displaced sharply inwards. Measured from the ground to a point immediately below the third level, the inward tilt of the outer wall into the wall void was measured at  $11^\circ$  out of the vertical. Angular displacement rather more than would normally be anticipated here. The condition of the third level would be explained by excess inward pressure that, with some additional circumferential force vector, destroyed well-set and unmoveable lintels and forced others out of their original radial configuration. The inventory elevation (Figure 133, upper) shows an unanticipated inward displacement of the inner wall also and this is discernible in Figure 138, just above mid height of the upper ope in the stacked void.



**Figure 138** The edges of the inner wall curve inwards to produce a conch-like form, a consequence of the failure of its surrounding wall, which pulled the remaining edges with it as it fell.

The inner wall, under pressure from the failing outer wall is compressed, circumferentially and in the vertical plane also, now forming a conchoidal shell of masonry. This is now under compressive pressure, vertical and horizontal, which pins the stones in place and their resistance

establishes a dynamic equilibrium that is probably not much better than metastable<sup>153</sup>. The lower gallery floors are formed from contiguous slabs that betray no evidence of major dislocation. However, their configuration indicates a complex history of build, failure and rebuild. These complexities are described below for the west and northwest areas of the broch, between the extant 12 o'clock stairway and the 3 o'clock cell.

### **Outer wallface**

The broch's outer wall, overlapping the edge of the knoll, was apparently built onto a challenging foundation (Figure 133) being, in the southwest quadrant built directly onto sloping bedrock (Figure 140 & Figure 140). Failures in the masonry on this side

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<sup>153</sup> That stability is threatened by the stacked void fragment near its vertical centre line because if this yields and allows movement of masonry from either side, the dynamic equilibrium is likely to fail and collapse of masonry may ensue.

can be identified in repairs to local failures, more or less immediately outside the areas of the intramural void described above. This is such a bizarre configuration as to prompt the speculation that when built, the broch rested on soil deposits formed above this rock exposure. These yielded to soil creep and fell away, taking a large slice of the broch with them and the broch was the rebuilt making such aberrant accommodations to the underlying bedrock as could be managed.

These masonry-discontinuity field-sketches indicate significant blocks of masonry in this area. They do not necessarily identify specific episodes of masonry failures or rebuilds but they demonstrate that the condition of the masonry of the outer wallface



**Figure 139 (above) The outer wallface of Dun Carloway on the southwest side (entrance just off the image to the left). A proliferation of fabric replacements is visible above and left of the bridging slabs over the bedrock. (below) A field sketch shows divisions between apparently different masonry masses**

outwith the rebuilds in the intramural voids does not contradict the hypothesis of multiple failures in the outer wall with likely consequences for the intramural void.



Pinnings in unmodified brochs invariably lie between adjacent building stones and do not extend between courses. Examples in the Carloway wallfaces (dark patches in Figure 140) that span courses may be identified as modern 'window dressing'

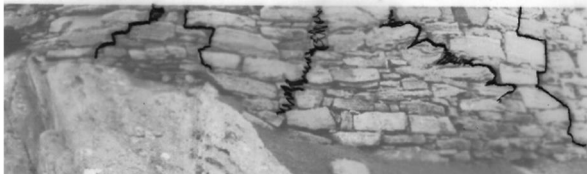


Figure 140 a (top) & b (upper middle) Wallface masonry right of the bridged bedrock.  
Figure 140 c (lower middle) & 140 d (bottom) Field sketches illustrate the main apparent discontinuities in the wallface on the southeast of the monument.

### The 3 o'clock guardcell

It is argued here that the anticlockwise end of the 3 o'clock cell once extended to the lintel over the crawlway (below and left of the notebook visible in Figure 141).

Under the notebook's right side is the first of a set of tuskings, stumps of the broken or slapped out corbelling of the original chamber. Three lintels can be seen to step



**Figure 141 (left) Tusings from broken lintels of the 3 o'clock cell.  
The lintel visible bottom right is a new insertion.**

upwards and to the right in the image, reaching the level of the new lintel (bottom right of the image) which was not part of the original cell roofing. The new lintel is set level with and in front of the uppermost tusk and is supported beneath by a curious mess of mortared stone<sup>154</sup>. The masonry opposite that shown in Figure 141, is very poorly constructed indeed and is interpreted as a later repair or insertion into the outer wallface of the inner wall or even a complete rebuild of the inner wall at this point.

### **Stacked voids**

Described in the Inventory as:

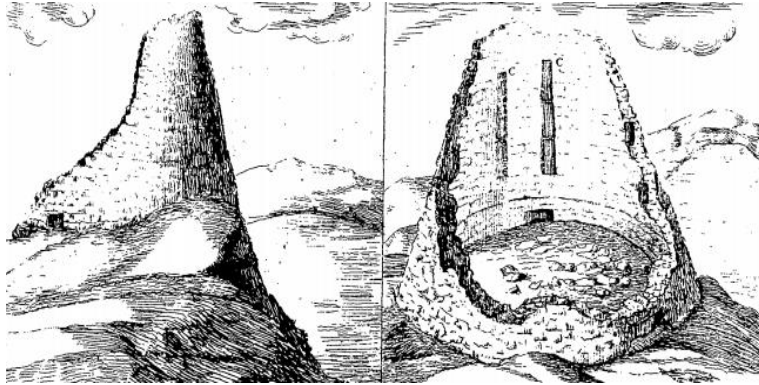
A void in the inner wall, 2½ feet wide, with vertical jambs, extends to the whole height of the two uppermost storeys in the high portion of the inner wall, and has a single transom at the third gallery floor level. (RCAHMS 1928, 19).

This feature has not changed materially since the RCAHMS observation of it, save only that its uppermost lintel is now displaced. Parallel cracks have opened on either

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<sup>154</sup> The new lintel is most likely another example of ill-considered conservation

side of the stacked void which should be a cause for concern. *Ad hoc* applications of mortar in the area have not achieved the stability intended and a more comprehensive



**Figure 142 (left) Dun Carloway prepared for McKenzie 1792 showing two stacked voids. (after McKenzie 1792, 287)**

treatment will soon be required.



**Figure 143 The relict stacked void fragment above the scarcement at Dun Carloway.**

part of it perhaps 0.6 to 0.8 m above the remainder, such gross dislocations need not be wondered at.

The Inventory makes no comment on the potential use or function of the stacked void, but Armit seems clear on the issue:

— superimposed voids for the ventilation of the intramural galleries are also to be found in some of the inner wall-faces of broch towers, as at Dun Carloway (Armit 1996, 112).

It has been argued above that stacked voids are a weight relieving structural response to the fragility of stone lintels. Tall stacked voids that reach to the wall head, as for example, at Dun Trodden, are associated with broch entrances, entrances to stairways and entrances rising from stair landings. The lower of the voids at Dun Carloway could have served as a high level access to the enclosed space; it is almost parallel-sided<sup>155</sup>. However, the upper void is slewed anticlockwise (to the left in the images) and this, it is argued here, results from continuing distortion and movement in the inner wallface. The masonry abutting the top right hand side of the void leans out over the garth, and this results from compression of the inner wall (above).

The width of the top of the surviving stacked void also militates against the belief that the height of the broch is more or less complete as Miers suggested (Miers 2008). All of the extant tall stacked voids reduce, in some instances to as little as 150 mm, at their tops (see the Glenelg brochs) and their struts proliferate as they rise. The belief that the whole of the monument's height survives at Carloway is predicated on the closure of the intramural void at or just above the surviving top of the stacked void. However, the traumatic convergence of the walls results from the inward displacement of the outer wall is not a reliable index of original height.

The inward displacement of the outer wall can be appreciated by comparing the outer wallface profile outwith the stacked void with that at roughly right angles to it (Figure 144). The former is kinked, inwards then outwards as it rises while the latter is a smooth conical surface throughout. The RCAHMS 1928 survey represents this position (Figure 133) quite clearly. The outer wallface, seen in the profile view, bends inwards close to the top of the second level gallery and recurves outwards, at least in its highest parts (projected onto the survey plane). In addition, the inner wallface tilts inwards from about the same level.

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<sup>155</sup> In general, the sides of a stacked void inclines towards its centreline by about 10°.



**Figure 144**  
Comparison of outer wallface profile outwith the stacked void (left) with that at right angles to it (right). The former is kinked and faceted, the latter linear (in the vertical plane) and smoothly curved (in the horizontal).

### **Acanonical Structures; the northwest quadrant**

The surviving stair, entered via the 12 o'clock cell and rising clockwise from inside the cell entrance, is clearly a composite structure comprising four distinct elements



**Figure 145 a, b, c and d; left to right. The intermural stairway in Dun Carloway.**

illustrated in Figure 145 a to d): the lower 7 steps (Figure 145 a); an apparent landing comprising 5 approximately level slabs Figure 145 b); a set of 9 steeply dipping and broken steps terminating at a build up to a higher level (Figure 145c); an upper set of

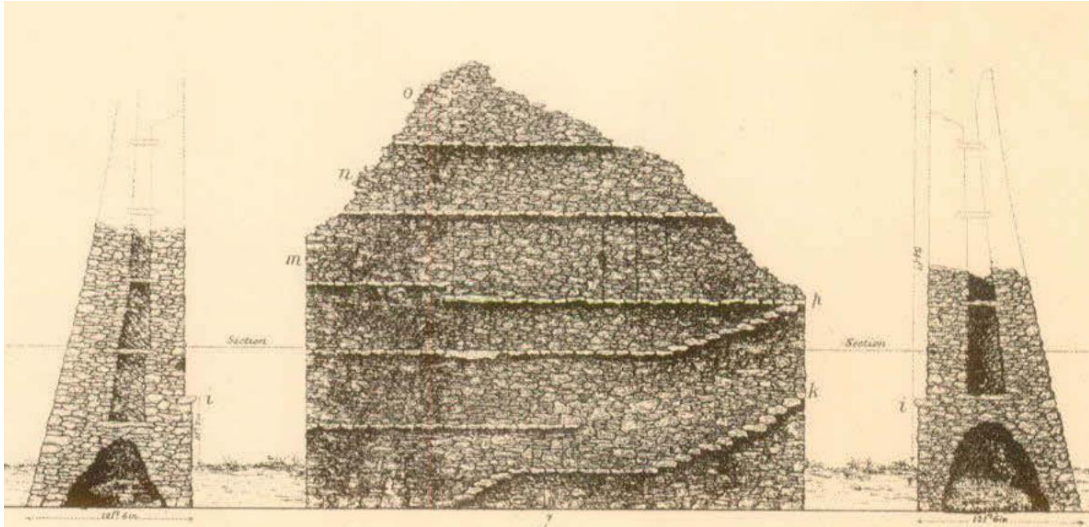


**Figure 146 A view down the composite stairway with the stepped risers visible at the top of the image.**

4 approximately horizontal slab steps completing the stairway (Figure 145 d). Stairways, in RSM tectonics, were designed to articulate between the ground level and the first two gallery floors (G/1 and 1/2). In the surviving section of the Dun Carloway wall, these two lintel levels are clearly visible (Figure 146), as are another two higher levels, albeit less clearly because less accessible, and more disturbed (above). These were the gallery floors, and in the text that follows, are contracted to (GF G/1), (GF 1/2), (GF 2/3) to represent between ground and first galleries, or first and second, or second and third, and so on.

Armit (2003), founding on the unpublished work of John Hope suggests that the inter-mural voids (galleries and higher void spaces) were intended to serve as a cavity wall intended to divert rain from the full conical roof down and back out through the outer wall; a necessity because the putative roof sits atop the inner wall and inside the outer wall. This is best expressed in the drawing (*op cit*, Armit's Figure 31; based on ideas proposed by John Hope). This drawing shows the outer wall's wallface in the 'milk-bottle' profile derived from Mousa and not evidenced in

any other broch<sup>156</sup>. Positioning the roof on the inner wallhead and inside the outer wallhead ignores the evidence from the Glenelg brochs that the walls converge below the wallhead (see the RSM and Chapters 6 and 7 herein). The illustrated



**Figure 147 Vertical and circumferential sections through Dun Carloway, from a survey by Captain Thomas published in 1890.**

arrows (*op cit*) imply a slope in the wall-stones of the outer wall's core, whilst in every case in which the evidence can be seen, these are rigorously horizontally placed (see for examples Dun Beag and Midhowe in Chapters 6 and 7 herein). Similarly, the gallery floor slabs are shown tipping down to the outside, in the figure, and except for the upper levels at Mousa and some isolated and clearly damaged areas of flooring elsewhere, the vast bulk of the observable slabs are truly horizontal, even in badly damaged brochs. Thus, the idea that rain can be deflected to the outside by the arrangement of gallery and wall core is not supported by the evidence.

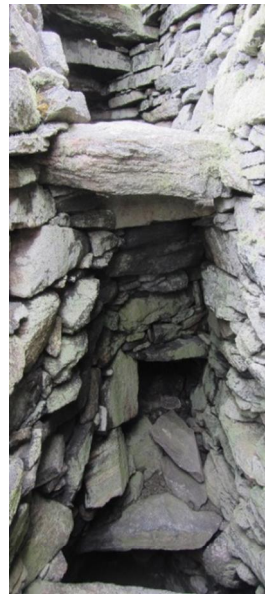
The survey of Carloway published in 1890 by Thomas illustrates the relative positions of the, then better preserved, gallery floor lintels reproduced here as Figure 147 (Thomas 1890, his Plate LI). The landing of the surviving stair is 0.94 m lower than the next gallery floor, per the Thomas survey, and 3.05 m below the next again gallery floor (0.91 and 3.05 m respectively). The upper stairway (now lost) abuts the

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<sup>156</sup> Selected profiles of Dun Carloway follow a similar but shallower curve but structural analysis shows that this is due to early collapse and rebuild episodes (see Chapter 6, herein).

base of a lintelled floor with no stair opening. These stairways cannot have functioned in conjunction with the planes of the lintels defining gallery floors in the 1890 survey (Figure 147) and the difficulties of interpretation they pose now as isolated fragments even of that which then survived are incomprehensible in the framework of a single build.

The wall cell at 3 o'clock, like the stairway, is a composite structure and the unpaved level surface above it that stretches towards the entrance, lies 1.16 m above the solum<sup>157</sup>. The upper surfaces of the lower two lintelled gallery floors lie 1.3 m (GF



**Figure 148 (far left): The highest cross void lintels are the floor of the 1/2 gallery. The highest stepped riser lies just below centre (in the far left image) and is aligned with its depiction in the left image. A poorly built transverse wallface can be seen below the risers. It rests on a lintel over the sub-stair void. Just above the bottom of the image, a capstone of the ‘tail’ of the 3 o’clock cell accesses a crawlway that apparently ran to the back of the stairfoot (Figure 133).**

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<sup>157</sup> Tabraham’s excavations in the 9 o’clock cell places the building level some 700 mm below the current solum (Tabraham 1976-7, 156), with bedrock a further c. 100 mm below the peat surface to which he measured (ibid, see his Fig 2). The current solum is relatively level and clearly formed on an introduced infill-deposit. Whilst imprecise, it is sufficiently level for use here as a general reference level in comparing heights of features across the broch, pending access to laser scanning data of the monument.





**Figure 149** A view along the intramural void entered from beneath the blocking wallface. The hand visible top left has been inserted from the landing element of the stairway.

G/1) and 2.73 m (GF 1/2) approximately<sup>158</sup> above the current solum [i.e. 2.01 m and 3.07 m, resp. above the Tabraham datum]. It will be clear that the un-flagged surface

over the 3 o'clock cell, at 1570 mm does not correspond closely with either of the first two gallery floor levels, but flagged over might match the lower. The plane of a gallery floor is just visible beneath the stepped risers in Figure 146. These risers

It is likely that these stepped risers are the foot of the stairway extending between the second and third levels, or part of the upper stairway illustrated in Figure 147.

The poorly built transverse wall inserted across the intramural void rises from a lintel, now underpinned with a bronze bar. It has probably been inserted to support the stepped risers but whether in antiquity or wholly by Historic Scotland is unclear.

The void under the transverse wallface extends beneath the stair landing. Figure 149 illustrates this space and the hand (visible top left) was inserted from the stair landing above it. Similarly, the lintel over the anti-clockwise end of the 3 o'clock cell can just be seen at the foot of Figure 149, and is part of the roof of the crawlway extending beneath the stairway, as indicated in the RCAHMS survey (RCAHMS 1928, here Figure 133). The crawlway was deeper originally, possibly 1 m deep if Tabraham's excavation result can be generalised to the whole monument.

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<sup>158</sup> The uncertainty is due to variability of lintel thicknesses, which are 80 to 180 mm thick. The cited measurements are taken from the average plane of the gallery floor surface.

It is concluded that the landing of the stairway is part of an original (G/1) gallery floor. This gallery floor would have passed over the top of the 3 o'clock cell and probably extended to the broch entrance. However, no evidence survives of the extension of this, or of any other of the surviving gallery floors towards the broch entrance. Had such lintels existed in the surviving masonry, some evidence of their erstwhile existence would have survived, as it does, for example, in the 9 o'clock cell. There, lost roofing lintels are indicated by tusking and lintel sockets (Figure 150).

Above the stair landing a flight of some 10 steps (DC3) survives in very poor condition. They dip down towards the outside of the broch at up to 25° and are detached from the inner wall, several of them being fractured (Figure 145 c). Their condition is explicable by a movement of the outer wall outwards and downwards from an original level at or just above the apparent landing.

At the top of the penultimate range of steps some levelling masonry was inserted and, above them, a group of levelled steps was inserted. The clinometer in Figure 145 c & d, rests on the lowest of this group of steps. Above this, a further build-up of



**Figure 150 (left) The stumps of broken roof lintels of the 9 o'clock cell visible in the inner wallface of the outer wall.**

small stones levels and raises the second step to about twice average rise, and the final steps, all horizontally set, rise above this in turn. These steps are not

very securely keyed into the stairwell walls and this may explain why a propping wall was built to support them. It is assumed that these are modern insertions or replacements.

On balance, it seems that a clockwise stairway originally connected the then ground level with a lintelled gallery floor at the landing level. Apart from the landing, no

evidence now survives for this floor. Above the current stairhead, and starting anticlockwise of it three stepped risers of a stairway connected two lintel planes whose vertical spacing is not harmonious with the those indicated by the surviving stair (see the Thomas survey Figure 147). Following a loss of structural integrity, a further stair was built from the landing level to the next lintel plane, but this, in turn was damaged by further movements in the masonry mass. Finally, the uppermost steps were re-levelled and built up onto the surviving remains, probably in an act of modern conservation. The lack of co-planarity between the surviving lintel settings make no sense as designed objects and can only be interpreted as the composite survival of non-contemporaneous elements, some inserted following major masonry failure of the outer wall with some dislocation of the inner wall also.

### **Towards a site biography**

It is likely that the broch was built resting on soils that rested on the sloping bedrock. Following some soil creep, these soils were lost and the outer wall on that side collapsed, at least locally. The gallery levels were re-set in the rebuild leaving now anomalous structural features in place. Evidence has been presented to show that the surviving stairway is a composite feature. It has been concluded that the observable part of the first flight of steps lead to a landing which had been a gallery floor extending clockwise onto or over the 3 o'clock cell and probably projected further, to intersect the entrance. Thus far, the arrangement could be considered strictly canonical.

Above and anticlockwise of the landing a system of gallery floors existed and still partly exist, that follow a design scheme that is eccentric to the landing level. These are evidence for a major rebuild following a major failure of the masonry on the crag edge. The deformed remains of the stacked void, either originally or subsequently, protected the lintel of a stairfoot's access passage from the garth. The second stacked void, observed in 1792 probably protected the entrance from the landing to the interior, and is now lost, possibly to conservation.

Masonry discontinuities have been observed also on either side of the bedrock exposures just south of east under the outer wall (see Figure 139 & Figure 140).

Field sketches reveal their reality and plurality. These building planes probably result from rebuilds following localised collapse/s.

The outer and inner walls have been compressed together above the second gallery and the inner wall has been forced in over its base in the south, under pressure from the inward leaning outer wall. That pressure has broken and dislodged many lintels from the third and higher gallery floors but some lintels survived the crushing forces and were driven anticlockwise by a torque force in the resultant of the decomposition vectors.

The repairs and alterations that are visible in the monument are largely consistent with its original tectonics. The pottery recovered by Tabraham is not inconsistent with a date in the range 200 BC to 200 AD. Whilst these dates do not establish the construction date for the monument, they reduce effectively to zero, the probability that the monument was extensively reused in the Early Medieval Period, in consequence of which, the original broch tectonic scheme survived.

### **Canonicity and Mutability at Dun Carloway**

The extant remains at Dun Carloway broch appear canonical as they stand. It is clear that it has not acquired the Iron Age and Early Medieval fabric alterations that remodeled the northern and eastern brochs, masking their canonicity. Nonetheless, a significant history of masonry changes can be discerned in the fabric and if these alterations are subtler than their northern and eastern equivalents, they are nonetheless just as important.

The primary vector of change at Dun Carloway seems to have been the natural forces of decomposition associated with construction on a challenging site. It is improbable that an original build rested directly onto sloping bedrock and hence the supposition here that soil deposits above the bedrock have been lost. Reconstruction onto the sloping shield of bedrock on the south side of the structure has allowed the outer wallface to slide from position on more than one occasion. The monument was rebuilt with modifications to the gallery spacing. The rebuilding preserved the form of the canonical broch, implying that the Iron Age use and reuse of the broch

retained the tectonics of its original build. The mutability of its fabric, exemplified in its several redesigns, was motivated by the need for repair of failures in the masonry; it was not motivated by social pressures to alter the form of the monument from its original conception. This implies a continuity of functional relevance, for which in this instance we may read, of social relevance.

Its current condition must be a cause for concern and it is probable that anything more than the low level interventions it now enjoys will require some significant down-taking of extant fabric. This would present an opportunity to test the hypothesis set out here and to date the monument by the excavation of the monumental fabric. To the extent that the hypotheses offered here are refutable, it is argued that they make an evidence-based contribution to the study of Dun Carloway and of brochs in general.

## Dun Telve broch

### Background

This is the outermost of three brochs in the short narrow glen, Glen Beag, in Glenelg. The broch seems to have been complete, or nearly so, into the nineteenth century and thus it attracted the attentions of many early antiquarians, (principally Pennant 1790; MacCulloch 1824; Curle 1916; Graham 1947; Young 1962; Robertson, 1970; MacKie 1975; 2007).

About one quarter of the monument now survives to five levels, over 10 m high, with traces of a sixth level. The ground level contains two cells, the RHS guardcell and a stair foot cell, and stairway at the 9 o'clock position. In the prevailing curious terminology this makes it a solid based broch. The monument is a 'Property in Care' i.e. it is in state ownership, and has enjoyed a long history of possibly unrecorded conservation.

The full circuit of the ground floor level is apparently complete and whilst it has a circular garth, the outer wall is markedly flattened in the southeast quadrant, resulting in wall thickness measurements ranging from 3.66 to 4.58 m. In this area the wall is a little over 1.95 m high, at which level a scarcement is formed of projecting slabs. A high level scarcement can be seen, c 9 m above the garth.

The stairway rises clockwise from its entrance at 9 o'clock, to the first floor level, (Level 2). MacKie, in 1989, observed what he believed was the lowest stone of a second flight of steps, originally discerned by Curle in c. 1920, some 5.7 m clockwise of the extant stairhead. This has since been removed (MacKie 2007b, 852; Curle 1921, 87). The ground, second and third level intramural voids are all brought to smooth faces, those above that level are roughly finished. The sides of the void converge with height, from 760 mm at ground level to 460 mm at the top of the second level and to 300 mm above this and less in places. MacKie (2007b, 853) argued that the upper galleries must have been originally wider to allow for stairway access to the wallhead, implying that this was the norm, but this suggestion cannot be reconciled with any credible modification of the surviving masonry. His suggestion that the outer and inner walls have been crushed together does not have

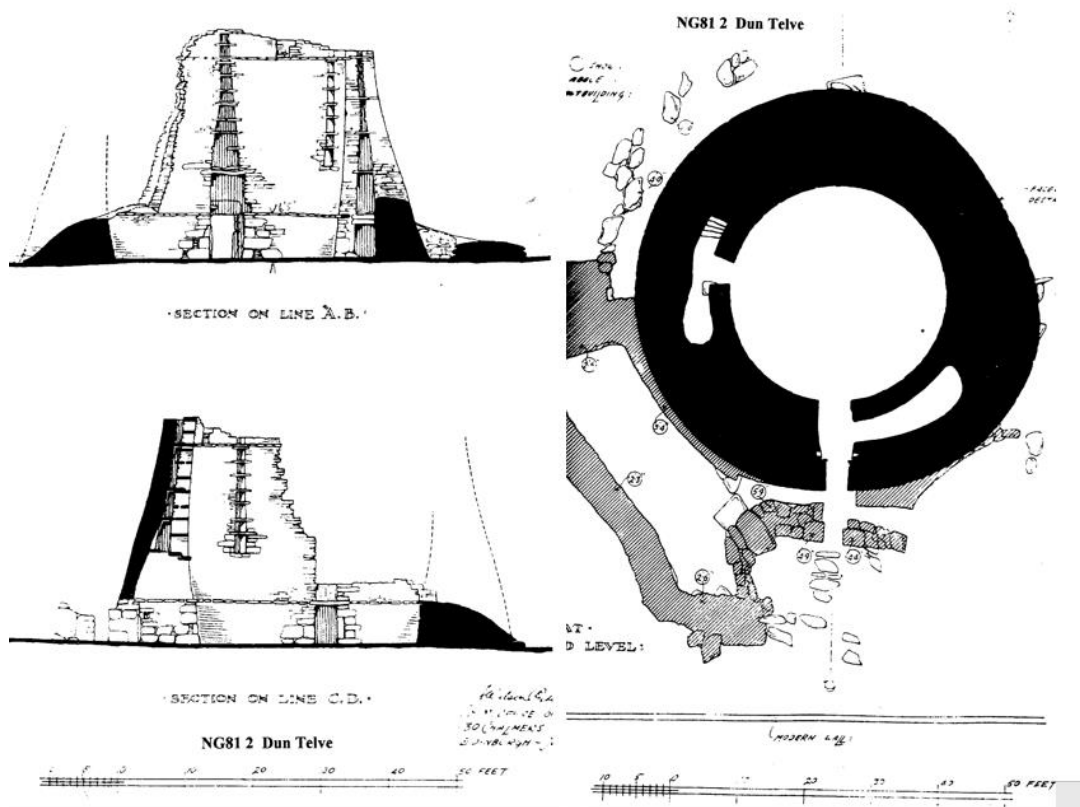


Figure 151 The OPW survey of Dun Telve, 1916, illustrates the surviving features. © RCAHMS

evidential support (see the caption to his Illus 166, in MacKie 2007b, 973). There is some local distortion of the masonry at the highest level, and in Figure 151 the inner wallface is displaced towards the outer wall by about 150 mm, locally. However, there is no evidence for systemic deformation in this monument's upper walls.

The surviving entrance passage is surmounted by the outer wall only. Behind this, the original stacked void straddling the inner end of the passage is still in place, albeit that several of its struts have been broken and some are lost. The 1916 survey (here Figure 151) indicates that the wall-end over the entrance to the stairway was probably the LHS of a stacked void also.

## Broch Anatomy

### Outer wallface; The entrance façade

Commenting on the high void immediately inside the outer entrance ope, created by the loss of the lintels of the first and second levels, as at Mousa, MacKie goes on to note that:

Unlike Mousa however there is no sign that the outer end of the passage has ever been extended upwards; the massive front lintel seems undisturbed, and there is no cement in the wall above it (MacKie 2007, 852)

MacKie claims to the contrary notwithstanding, the entrance to Dun Telve gives clear evidence of having been refashioned. A neatly built bulge of blocky stonework above the entrance extends to either side of the current outer lintel and upwards for about 12 courses; perhaps a little less than 3 m. This is clearly visible in photographs taken tangentially to the broch, but is also discernible in frontal views of the masonry (Figure 152 a & b).

It is necessary to conclude that like Mousa and indeed Midhowe, the entrance to Dun Telve became inaccessible at some time and a rough ope was slapped through the



**Figure 152 a & b The bulge of restored masonry over the entrance at Dun Telve. In the frontal image the rebuilt occupies the greater part of the image area but differences are obvious between the rebuild, mainly of large squarish blocks of stone, and the original, mainly of the relatively thin flat slabs visible in the upper left and right corners of the image. Image b (right) shows the bossing of the inserted masonry, out of line with the smooth conical surface of the outer wallface behind it, as viewed here.**

outer wall above the level of the current entrance. If the infilling of the entrance passage were a gradual process, this might also explain why the passage lintels were slapped-out. The implication here could be that the broch partly collapsed into the garth and/or that settlement in it had simply accumulated deep deposits and that later



(but still prehistoric) settlement over the debris required access<sup>159</sup>. Thereafter, the entrance was reformed, in the rebuild that is now visible. However, it is equally possible that the rebuild is a modern closure of an opening forced through for *ad hoc* use or for settlement access within the remains of the partly collapsed broch and this writer inclines to that conclusion.



**Figure 153 The outer wallface at ground level includes many very large stone blocks and slabs.**

The build quality of the outer wallface is uniformly high, and rendered especially impressive at ground floor level by the inclusion of many very large stones,

interspersed with panels of pinnings (Figure 153), albeit that not all of the latter may be original. Assuming the largest are in fact flat slabs inset into the wallface, their presence may represent a secondary refurbishment of the broch. Inset slabs are commonly associated with the village settlements and secondary structures within east coast and Northern Isles brochs (Chapter 6).

## The Inner Wallface

The upper inner wallface is a superb example of the drystone mason's work at its best. The thinner mudstone slabs between the upper scarcement and mid-height have fared rather badly but the bulk of the wallface between the stacked voids is of very high quality and has preserved very well indeed. Romankiewicz suggests that the masonry between the stacked voids is a rebuild (Romankiewicz 2011, Vol 1, Illus 136), based on the difference in the size and type of stone used in its construction (Figure 154). This is not inherently improbable but requires stronger evidential

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<sup>159</sup> Dryden's survey of Telve in 1873 (see Romankiewicz, T (2011). *The complex roundhouses of the Scottish Iron Age*. Oxford, BAR. Vol 2, 355 for reproduction) shows rubbish filling the interior almost to the level of the entrance lintels.

support than can be gained from masonry patterning alone. The quality of the build or rebuild is such as to suggest that the work is Iron Age and not modern.



**Figure 154 The inner wallface, like the surviving outer wallface is extremely well built and has preserved in relatively good condition throughout. The quality of the build is indicative of Iron Age construction rather than overactive modern restorative conservation.**

The appearances of the outer and inner wallfaces of the broch are, however, deceptive and its overall condition is somewhat less than perfect. Close examination of the vertical section drawn in 1916 (reproduced here as Figure 151) reveals distortion to the inner face of the outer wall within each of the galleries. In addition, examination of the northern edge of the broken wall at mid-second gallery height shows a net displacement of the inner wall, which has moved outwards toward the centre of the gallery. The latter can be seen in Figure 155, which also reveals a large intact slab above it that seems to bridge both walls. It also reveals breakage of the lintels just above the bulge of the inner wall's outer wallface into the intramural void and displacement of the lintel below it.

Together these observations point to localised damage caused by a local outward displacement of the inner wall.



**Figure 155** A localised defect in the inner wall on the northern edge of the high masonry at Dun Telve. The squared return at the foot of the image marks the line of the edge of a stacked void (subsequently conserved), beyond which the wall fabric bulges inward, breaking and displacing lintels, above and below. The neatly squared return on the lower outer wall is wholly an artefact of conservation.

## The Scarcements

Dun Telve has two scarcements, an upper, at c 9 m, and a lower set c 2 m, both measured above the current solum and both apparently original. The lower scarcement (Figure 156) survives around about two thirds of the inner wall circuit. It comprises single and double projecting slabs and most of them have been shattered. The innermost lintels of the entrance passage and of the stairway entrance were



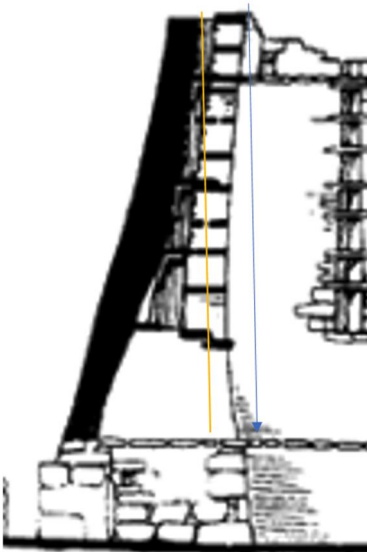
**Figure 156** The low level scarcement elements in this scarcement. The higher scarcement is preserved in the less than a third of the circuit that survives to near full height. It should be noted that the stacked voids at the entrance and the 8 o'clock position continue above the level of the upper scarcement.



**Figure 157 The high scarcement**

The high scarcement, c. 9 m above the solum, comprises one or locally two layers of stone slabs projecting from the wallface by 300 mm an average, albeit that several are broken. Both of the surviving stacked voids rise through the upper scarcement, the over-entrance stacked void rises at least two segments higher. A further, high-level opening pierces the inner wallface about midway between the stacked voids with its threshold set at the level of the higher scarcement (Figure 157). It is possible that this ope provided access to whatever structure was formed on the high scarcement, or more correctly, access from it since there was no other structural means of accessing the wallhead.

### **Displacement of the inner and outer walls**



The vertical and horizontal concavity of the inner wallface is appreciable to the observer within the broch, but hard to portray photographically. However, the OPW 1916 survey illustrates this clearly (Figure 158). The inner wall now forms a conchoidal masonry shell preserved, under its own self-compression, in meta-stability.

**Figure 158 This enlargement of part of the 1916 survey (see also Figure 155) has been marked with vertical lines to illustrate the inward pitch of the inner wallface, under pressure from a displaced and deformed outer wall.**

It should be noted however that the gallery floors are largely level and with very few exceptions the individual lintels are intact. There are signs of significant compression

damage in the masonry above the fifth transverse lintel in the stacked void (see



Figure 154) which is consistent with the compression arising from the inward tilt and concave curving of the surviving inner wall.

At Dun Carloway, similar inward pressure had broken and displaced many gallery floor lintels because the inner wall had resisted deformation to a greater extent. At Dun Telve, the relative proportions of the gallery cross-sections have been conserved. In both cases, the evidence indicates that the intramural void narrows with height in the broch, as the outer wall converges on the inner. Thus MacKie's assumption that the wallhead was accessed via intramural stairways is simply not

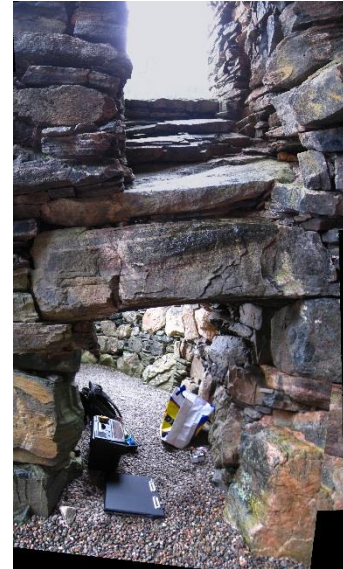
The wall itself is composed of two shells, one perpendicular; the outward one inclining inwards, and fastened together by the large cross stones which form the stair-cases. In the side of the ruins, I passed in at one end of these stair-cases, and, in a bent position, descended to the bottom, where I came out below, at a very low opening: But I found it impossible to get to the higher parts; and, as the wall gradually grows narrower, I cannot comprehend how people could get up to the top. (McKenzie 1792, 288)

supported by the evidence (see MacKie 2007b, 856, *Level 6*). Only the lowest two galleries above the ground floor level have wallfaces brought to fair faces. Above this level, the walls are rough and uneven, as well as being extremely narrow. Even allowing for the displacements of the walls at Dun Telve, it is unlikely that the



**Figure 160 (left)** The bar receiver and jambstone, adjacent to the guardcell entrance.

**Figure 160 (right)** The guardcell entrance, above the entrance lintel of which, the lintels of the guardcell roof can be seen stepping up to its full height.



galleries above the second were ever much more than 300 mm wide, and that on average only, as projecting stones narrow it even further in places. Perhaps the final word on the issue can be left to Colin McKenzie's 1782 comment on Carloway:

## Canonical structures

### The entrance passage

The broch is entered from the west and the passage is rather irregular. The outer part, to the doorjambs (and beyond that on the RHS) has divergent sides, the passage widening from the entrance inwards. It is c. 0.95 m wide on average. The doorjambs are 1.5 m into the passage and are formed of stone slabs and while the passage walls step back a little here, the jambstones also project slightly into the passage space. Beyond the jambs, the passage is 1.3 m wide. Its LHS is concave in plan and continuous to the interior. The RHS is pierced by the guardcell entrance and the narrow strip beyond that entrance is kinked. The small hole on the RHS has been identified as a bar receiver (Figure 159) as a matter of convention. The corresponding LHS hole should be the bar-hole, but it pierces no deeper into the wall than does the receiver hole. As currently configured, these features are non-functional.

All except the outermost lintel of the entrance passage have been slapped out but whether as a result of anthropic interference or of structural failure, cannot be determined unequivocally. The writer, taking into account the reforming of the

masonry above the lintel, inclines to the view that the *in situ* lintel may be a modern replacement for robbed-out stonework.

## Guardcell

Dun Telve has a single guardcell on the right hand site of the entrance passage. It is c 5.5 m long and entered via a low doorway ope from the entrance passage. In plan, the cell is somewhat lobate and although the innermost end is corbelled, the cell was roofed with lintels. The stepped lintels of the outer end and entrance passage of the guardcell can be seen in the intramural void above the cell from within the broch entrance passage (Figure 160)<sup>160</sup>.

## The ground gallery

No ground gallery now survives. There is evidence at the 8 o'clock position for a significant wall failure (above) and the bar-hole on the entrance passage LHS is blocked off. It is not impossible and may be considered probable that the structural failure had more extensive ramifications and that an intramural gallery, or LHS guardcell existed originally and has been infilled, to stabilize the structure. Only excavation of the surviving masonry could clarify this speculation.

## Levels 2 to 6

As noted above, levels two and three were accessed by intramural stairways, only the lower of which survives now, but one step of the upper was observed by MacKie in 1968. The accessible galleries are brought to fair faces; those above remain as coarsely finished stone wallfaces. For the reasons advanced above, Dun Telve was neither accessed nor accessible above the second gallery. The broch wall and its galleries seem to have been complete or nearly so in or about 1720 (Gordon 1726) but in 1722, some 2.29 m of stone had been stripped from the top of the structure (Pennant 1774). It can only be regretted that having survived for more than 2

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<sup>160</sup> But note the distortions of the panorama-making process here. Panoramas are necessary despite the small areas involved here because the narrowness of the passage makes it impossible to record the whole cell entrance in a single exposure.



**Figure 161 a & b. Dun Telve, the stairfoot. The counter stairfoot cell (left) and the ground floor stairway (right).**

millennia, the wallhead of this near intact structure was lost to us only 2 centuries ago.

### **Stairfoot cell**

The entrance to the cell has been commented upon above for the slight remaining traces of a stacked void above the entrance. The counter-stairfoot cell (Figure 161) is well built from large square blocky stones and is lintelled over. The sidewalls of the stairway diverge as they rise but their current condition militates against this being other than a design characteristic. If the fine finish of these sidewalls has been embellished by modern conservation, it has masked any evidence, like opening of the joints, etc, for early traumatic changes.

### **Redundant stacked void at the 8 o'clock position**



Noting this stacked void, and its lower termination at about the top of the second level, MacKie suggests that it has no obvious function and may simply have provided lighting to the intramural void (MacKie 2007b, 853). Earlier writers and surveyors, including Curle and Patterson (see MacKie, *ibid*, for details) have also noted the presence of blocking slabs that cross the gallery beneath the surviving void,



**Figure 162 a Dun Telve, (left) the stacked void at the 8 o'clock position in the inner wallface at Dun Telve. b (right) The inter-mural struts that propped the edges of the now closed-off stacked void segments below the surviving elements.**

at the second level, i.e. between the scarcement and base of the stacked void (see right hand image in Figure 162). That their presence has obstructed passage around the gallery has been noted but no explanation of their presence has been offered. It is

here proposed that these are the side props of the downward continuation of the 8 o'clock stacked void whose opening to the gallery has been walled in.

Stacked voids possess the more familiar transverse struts, or lintel-set horizontal in the plane of the inner wall but also have struts that prop the inner wall edges against the inner wallface of the outer wall (see Dun Troddan, below, for example). Ironically, in the light of MacKie's suggestion, the light reflected from the wallface beyond the cross slabs in the right hand image entered the intramural space via the surviving stacked void above it.

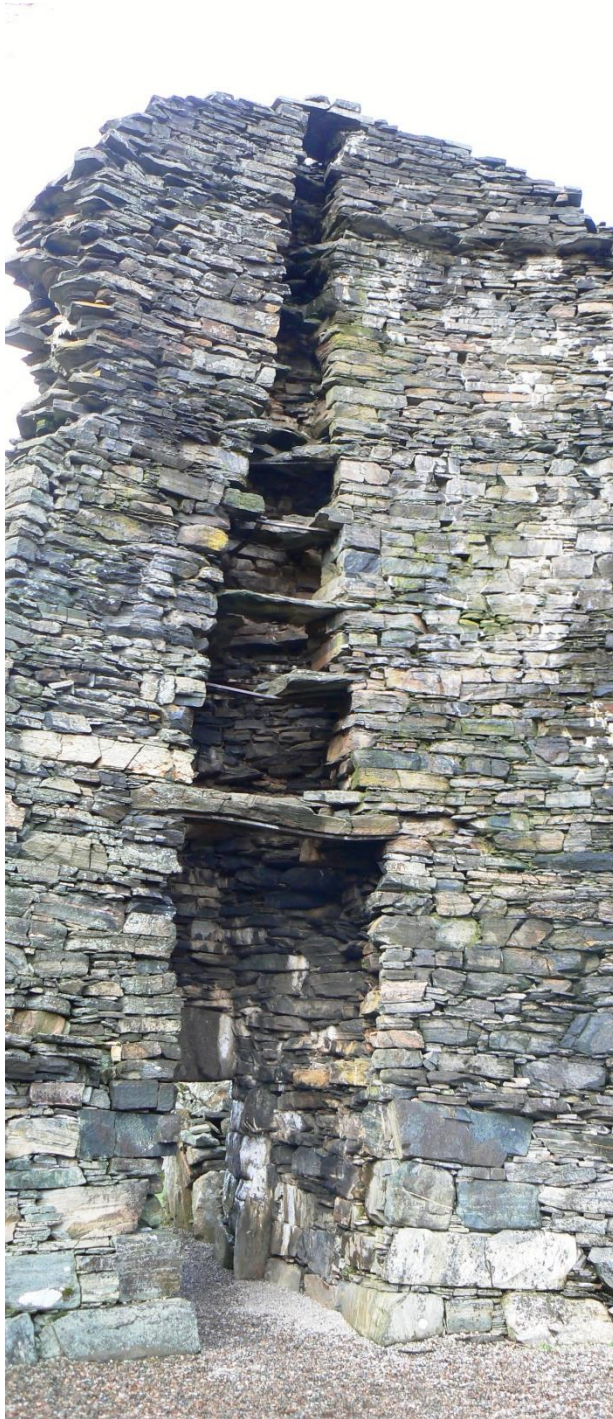
Examination of the masonry beneath the 8 o'clock void suggests that it has been replaced or reworked, or at the very least that its condition is not inconsistent with the closure of a failed void. It is tempting to see the first level void, now lost, as providing a doorway onto the floor resting on the scarcement beneath it, but this must be improbable because the cross slabs would have impeded access from the gallery. Examination of the inner wallface does not rule out the possibility that a ground level void had existed at this position. Certainly, the condition of the scarcement at this point and its height differences on either side of it suggest that some significant distress has been suffered by this masonry.

Had the 8 o'clock stacked void continued to ground level, its function would have been to relieve pressure on an entrance lintel giving access to an intramural feature, a cell, gallery or stairway, that has similarly now been lost. To pursue this matter further would be mere speculation, but it may be concluded with confidence that these structural features constitute a relict stacked void that has no structural function within the surviving remains. Its significance for the current study is that it provides an example of a highly canonical original structure that has undergone significant mutation, but without loss of canonicity.

### **Stacked voids**

The stacked void above the broch entrance passage is clearly damaged and incomplete. The continuations of the gallery floors across the void are absent from

the first three galleries and broken in whole or part in the others. The left hand edge inclines toward the centre line of the void, whilst the right hand edge is close to vertical. The images offered here are not true representations; the photograph (Figure 163) suffers from parallax distortions and the survey image from over correction (Figure 151). The true representation lies somewhere between them.



**Figure 163** The entrance stacked void (left). It is clear that several transverse struts have been lost and many of the surviving struts are broken. The image below illustrates the poor condition of many of the remaining struts in this view up through the entrance stacked void.



Euan MacKie has observed the possibility that the stone courses immediately above the stair entrance lintel on the left hand side in this image may be all that remain of a stacked void that once sat over the stairway entrance ope (Figure 164). While the evidence is not unequivocal, this writer on balance agrees with Mackie's interpretation. If correct, this might explain how access was secured to the flooring



**Figure 164** The first four courses above the left hand edge of the stair entrance ope in the inner wall, on the basis of the 1916 survey, forms part of a lost stacked void return. The right hand edge seems to confirm this identification but may have been rebuilt.

above the scarcement following the failure of the 8 o'clock stacked void and its subsequent infilling.

## **Towards a site biography**

The broch of Dun Telve is a relatively well preserved monument which in whole and in its substructures, is quite consistent with the RSM broch under discussion here. It is implicit to MacKie's 2007 description of the monument that it was constructed, effectively as it now is and that any alterations are to be interpreted as consequent upon the loss of fabric, sadly most of that occurring over the past two centuries. The

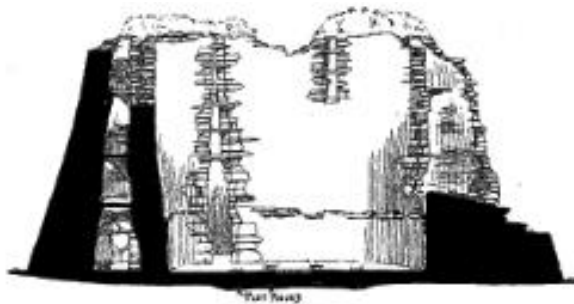
writer demurs somewhat from that position and argues that the failure and reconstruction of the 8 o'clock stacked void and the fragmentation of the lower scarcement indicate a localised, traumatic failure of the original structure and its subsequent reformation, largely to the original plan, but making the stacked void a relict feature. Attention has been directed to other, even more subtle problems in the masonry of the monument which, if they do not confirm this hypothesis, certainly do not confound it.

It is concluded therefore that an original RSM broch underwent significant destruction by natural decomposition and was extensively repaired, possibly partly or substantially rebuilt. Although containing relict features, the surviving monument is neither acanonical, nor antagonistic to the original broch tectonics. There is no evidence for later construction within the garth and only superficial building outside the entrance area. Thus, and in contrast with the Orcadian and North East Mainland sites, the broch's fabric was not refashioned for reuse, or as a source of building material for subsequent large scale developments of slight structures in and around the broch in the Middle and Late Iron Age and the early medieval period.

## Dun Troddan

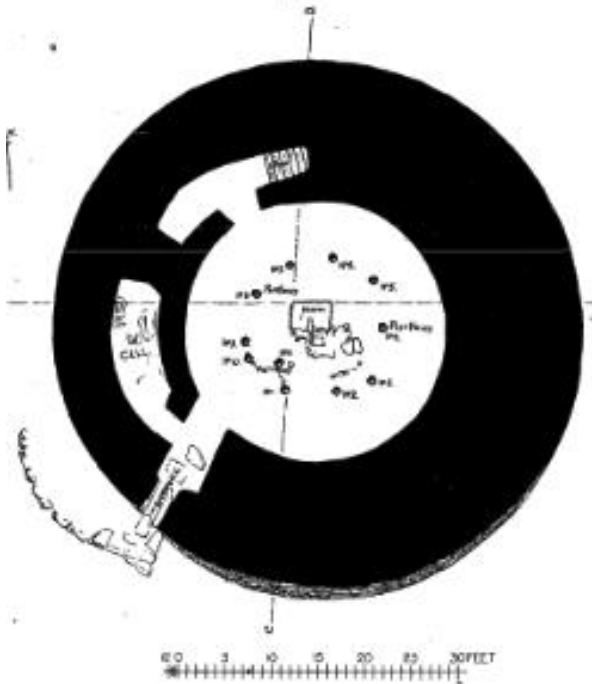
### Background

Dun Troddan is similar to Dun Telve in its original organization and in the quality of its survival, and given that they are separated by about less than 500 m, this is hardly surprising. Like Telve, Dun Troddan was largely stripped of fallen material inside and out, before 1920 (Curle 1921, 5; see Figure 165). It is also a Property in Care, and has similarly experienced undocumented conservation interventions over the last century or more. Possessed of a guardcell and a stairfoot cell and stairway, it is a solid based broch in the prevailing terminology. For about one third of its circuit,



parts of some three galleries, the uppermost unroofed, survive above the ground level.

Figure 165 (left) Dun Troddan broch, plan and elevation (after Curle 1921).



The ground floor storey is 2.1 m high and may mainly comprise a solid build, apparently containing only the entrance passage, guardcell and the stairway complex. The masonry of the outer wallface is of very high quality indeed with some very large stones and panels of pinnings forming a smooth coplanar surface, always assuming these latter are original.

The now roofless entrance passage is not radial to the broch and has been narrowed significantly on the outer RHS, level with the LHS door check. A bar hole abuts the LHS door check. The entrance passage, if not acanonicaly built, has been remodeled, probably mainly on the RHS. The guardcell presents as a widened gallery

segment and was probably roofed with lintels, some of which, towards the rear of the cell, are still in place.

A full-height stacked void in the inner wall rises from the entrance to the stairway, the lowest lintel being now lost and several others damaged or also absent. It reduces in width from 750 mm at ground level to about 150 mm near the wallhead. A further stacked void is postulated by MacKie above the entrance to the stairway, the LHS of which is brought to a fair face for a height in excess of a metre. Gordon's account of the broch describes it as largely intact in the 1720s (Gordon 1726) and MacKie relies on Gordon's description in support of this interpretation.

The stair climbs to the right (clockwise) and its ninth step forms the first lintel of the floor of a long landing (per MacKie 2007, 857) or a gallery. The garth appears orthogonally circular at the current solum and was measured by MacKie in 1971 at 8.56 diameter (radius  $4.28 \pm 0.03$  m).

A scarcement is observable in the inner wallface at c. 1.8 m above the solum. It is formed from projecting slabs and these are doubled in some areas, while elsewhere it is formed by an inset in the inner wallface (MacKie's ledge type)<sup>161</sup>. Given a ground level wall height of 2.1 m, this scarcement runs between 300 and 600 mm below the lintelled floor of the passage from which it is believed to have been accessed. This is anomalous, not so much for the height difference but because that difference is so variable. As the most unsupported of speculations the writer wonders if the ledge scarcement may indicate an ancient failure and rebuild from the level of the scarcement, at least of the inner wall or wallface. This might explain the contrasting styles of scarcement which are obviously not consistent with a truly circular inner wall, and yet the wall is truly circular at its base.

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<sup>161</sup> MacKie's 2007 Figure 8.184 presents a good image of the scarcement clockwise of the stairway.

Gordon noted a scarcement at a higher level in 1726, but nothing of this now survives; however, Troddan's similarity to Telve in other respects lends a tenuous support to Gordon's observation (Gordon 1726).

The removal of 5 ft of debris from outside and 4 ft from within Dun Troddan was well advanced before the arrival of the archaeologist, Curle, who was allowed to observe and intervene in the further works. Only a central, rectangular, paved hearth remained in the garth, overlying a gravelly subsoil and this must have been projecting from under an area of apparently undisturbed deposits within which he found a series of layers of peat ash and paved surfaces. Beneath all of the deposits, he found a group of 11 post holes that had been excavated into the subsoil. These are said to form a rough circle some 15 ft in diameter. The SM2012 form is predicated on Curle's belief that these posts supported a simple roof, later writers preferring the mezzanine structure of the SM2012 (Chapter 3, Figure 26; see also Chapter 3, Scarcements ).

Assessment of the original height of the broch ranges between 10 and 12 m, or thereto, and these are not inherently improbable estimates.

## **Current interpretation/s**

The exceptionally long history of records of this broch is a positive aid to its interpretation, albeit that the documentary evidence itself first requires interpretation. SM2012 has hitherto been used to interpret the broch in the light of the extant documents and its reexamination here has concluded that Dun Troddan is a typical RSM broch. Since this is one of the five monuments preserved above the second level, upon which both the Standard and Revised Standard Models are based, it is inevitable that Dun Troddan appears canonical. Giotto might have enjoyed the circularity of this reasoning, but even if the models are not refuted by Dun Troddan, it is clear that they could have been, as indeed and more clearly could have the northern brochs which seemed strongly antithetical to the RSM canon when this work began.



Nonetheless, some slight indications of alterations to the broch have been recorded. The disparity in height of the gallery floor and the extant scarcement, the eccentricity of the scarcement and the remodeling of the entrance, at least on the RHS, taken together may point to the conclusion that a remodeling of the monument itself followed some structural failure, or failures, for which no other evidence survives. These are rather subtle effects and alone are probably insufficient to support the hypothesis.

Dun Troddan is a canonical broch in RSM terms displaying some evidence for alteration but within the original tectonics of an RSM broch.

## Broch Anatomy

### The outer broch wall

The use of larger stones closer to ground level is illustrated in Figure 166, in which can also be seen the finely fitted panels of pinnings between the main structural



stones. This image also gives evidence for the bringing-to-level of the ascending wall.

Overall, the broch wall masonry is of very high quality and the conical plane of the wallface is closely followed and clearly demarcated.

**Figure 166** This c. 4 m high section of the outer wall at the 9 o'clock position illustrates the transition from large stones ( $\approx 250 - 500$  kg in mass) at the lower level to a relatively standard smaller ( $< 25$  kg) stone size above c. 2 m high.

### The inner wallface

In general, the inner wallface is as well built as the outer but there are some anomalies in its construction. In particular, the small scale pinning-panels observed in the outer wallface are replaced in areas of the inner wallface with large expanses of pinnings. It is

unlikely that these have any significant load bearing capacity and their absence from other brochs, taken together indicate that these are probably modern efforts both to stabilize and to improve the aesthetics of the monument.

## The scarcement



**Figure 167** The inner wallface at Dun Troddan illustrating the scarcement level.

The inner wallface panorama reveals the scarcement (Figure 167) and the difficulty in seeing it there, apart from the extreme reduction involved, is repeated in the real world because this scarcement is poorly formed, partly broken and variable in its height above the solum. This mixed scarcement is inconsistent with a right cylindrical form to the inner wall. Left of the stairway it is a ledge in the built masonry, right, a projecting slab construction<sup>162</sup>. The untidy execution of the construction of the scarcement is inconsistent with the high quality of construction exhibited in the wallfaces. Its variability of form, existence (there are significant gaps), carrying capacity and altitude would, as they now stand make it difficult to anchor a large structure onto it with confidence. The condition of the scarcement points to a history of damage and probably of rebuilding which would also account for the height difference between it and the first-level gallery floor from which it was accessed.

## The wall adjacent to the entrance

In the area of the entrance the wall is clearly thinner than elsewhere around the broch's circuit, as represented in the 1921 plan (Figure 165). This may in part be due to measurement at different heights, but allowing for that a difference of c. 500 mm

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<sup>162</sup> That these are not simply artefacts of the panorama software used to produce Figure 167 is demonstrated by the OPW survey published by Curle and reproduced above as Figure 165

is nonetheless detectable. In addition, the outer wall right of the entrance is only two thirds of its thickness left of the entrance passage. The entrance is itself anomalous (above) and the formation and thinness of the RHS of the wall would have provided very little security against determined pressure on the door. Although a rough sketch, Gordon's illustration of the broch exterior shows a large hole in the wall at ground level, where the original entrance may have been grubbed out or simply failed. The LHS guardcell is discussed below, but it also points to a reforming of the masonry in that area.

## Canonical structures

### The Guardcell



**Figure 168 a & b** The LHS guardcell, (a, left) looking towards the entrance and (b, middle) back of cell and (c right) The guardcell entrance.

The guardcell is well built, indeed rather massively built with steeply inclining sides and with lintel roofing surviving only at the rear (Figure 168 b). A clear rispain joint exists on the right, looking out from the cell, between the rather craggy masonry of the cell wall and the rectangular and blocky face of the entrance passage wall (Figure 168 c). In addition, the cell wall to the right of the image in Figure 168 b is absurdly formed, with vertically set slabs embedded in the wallface. If this is not a modern conceit of conservation, then it is further evidence of earlier failure and repair of the wall fabric at the entrance.

## Stairfoot cell

The side walls of the stairfoot cell curve inwards to form a somewhat keeled rear end which gives the impression of corbelling but it is not in fact corbelled. It is roofed with the lintels that form the floor of the gallery above (Figure 169). No credible evidence could be observed for a breach through the outer wall's inner wallface



Figure 169 the stairfoot cell, (left) viewed from the entrance and (right) its roofing.

between the cell and stairfoot that might have matched the blocked breach in the outer wallface (below).

## Stairways

The stairway is RSM canonical and the quality of the build and control of the three-dimensional curves of its side wall, especially the inner wall, is quite remarkable. It comprises nine steps giving access to a landing. This landing is simply an element of the first level lintels, roofing the ground level cells and flooring the first gallery.

## Stacked voids

There are two stacked voids, one over the entrance to the stairwell (the stair void) and one clockwise of it (the high void) that only survives high above the current solum. The descriptions provided in Curle and Mackie are detailed and replete with

measured data, and may be consulted by the interested reader. Here their surviving condition is considered for its merits in assessing the structural biography of the monument.



**Figure 170 a & b The stacked voids at Dun Troddan, a (above) the voids over the stair entrance and b (right) the high level stacked void and the masonry beneath it.**

The stacked void at the stairway entrance (Figure 170) is now asymmetrical in the vertical plane, its transverse struts are fragmented and some are missing, especially those at the lower level. It is obvious that it has undergone significant structural trauma which will have originated in circumferential stress in the structure. However,

it is probable that human intervention, partly in removing struts and later perhaps in conserving the stack edges, have complicated the surviving remains.

The masonry under the high stacked void is replete with large panels of pinnings many of which atypically cross building levels. The scarcement is absent from under the high void and rispain joints extend from the scarcement level to the current solum. Even accepting that much of the pinning may have been inserted in the recent past, what remains is consistent with the loss of a large area of the inner wall or, at least of its inner façade. Again, the evidence is not unequivocal and the hypothesis



**Figure 171 a & b. An infilled breach in the outer wall outwith the stair cell entrance. Both images are panoramas and parallax distortion is obvious but the inseting of the wall is clear and is real.**

could only be tested by the removal of part of the broch wall, an action that is unlikely to occur given the loss of the cultural value of the existing wall that would ensue.

## **Acanonical Structures**

### **A blocked breach in the outer wall**

At a point on the outer wallface outwith the locus of the stairwell entrance, an area of recessed stonework can be observed (Figure 171 a & b). The stones used to infill the space include atypical rounded boulders and are inset behind the inclined and curved plane of the wallface. This is interpreted here as an infilled access point into the broch. It is not clear that it had been formed into a structured entranceway. It may have formed an informal access to a monument already in ruins. However, as noted elsewhere, some brochs had a secondary entrance forced through the outer wall at the stairfoot, and it is not impossible that this is a further example, despite the apparent lack of formal framing. Such entrances have been argued to be substitutes for the original entrance following its damage or loss. However, the broch was fairly complete in the eighteenth century and this requires that the loss of the entrance and its rebuild and sealing off of this secondary entrance had taken place before then, i.e. in antiquity.

### The post hole setting

Upon the 11 postholes revealed by Curle in the garth of Dun Troddan rests a great burden of subsequent interpretation. Analysis of the published plan reveals that the posts are not concentric with the broch and they do not form a circular setting. Drawing the bisectors of the centroids of the post positions, it is not possible to find a centre from which more than three posts can be inscribed in a perfect circle, in all but one case, and of course a circle can be drawn through any three non-linear points. Post hole positions 7 through 10 can be so inscribed and even then, the circle just cuts the edge of 10.

The centres resulting from bisection lie within a circle that is 1.35 m in diameter so that the distribution of postholes are unlikely to have formed a circular setting around a poorly defined common centre. Measured from the centroid of all the individual post holes, the posts occupied an annulus that is 900 mm wide. MacKie describes the post hole setting at Troddan as forming a rough circle (MacKie 2007b, 859) within a garth whose radius he has measured as  $4.28 \pm 0.03$  m, i.e.  $\pm 30$  mm (ibid, 857). The setting out of broch structures was undertaken to a high level of precision, a view which MacKie's own work supports, and it is therefore hard to reconcile such precision in stone building with the imprecision of the setting out of the more easily

managed inner furnishings of the monument: the stonework is 30 times more precisely laid out than the wooden structure. This is challenging news for SM2012 which uniformly illustrates the lean-to structures or mezzanine floors as symmetrically disposed about the garth, and the main evidence for this has been the post hole setting from Dun Troddan. Whatever structure the post holes contributed to it can be reasonably be asserted that it was not the regular, concentric, circular tiers of mezzanines of the SM2012, which remain a work of high imagination.

Euan MacKie has also suggested that the nature of the earliest depositions supports the conclusion that the tectonics of the broch had altered between, on the one hand, the initial construction with its putatively contemporary post hole structure and subsequent decay of a wooden structure and, on the other hand, the subsequent use of the garth space.

MacKie suggests, Curle records and others imply, that the post ring predated the other deposits, presumably by an interval sufficiently lengthy to permit the use of the post structure followed by its decomposition and decay; possibly more than one decade but probably less than a century. MacKie, perhaps with a paradigmatic presumption of continuous settlement on the monument, seeks to reduce this interval to a minimum, suggesting that the post structure was dismantled and removed before quantitatively different habitations of the tower [occurred] (Mackie 2007, 860). Curle, however, had already presented unequivocal evidence against this interpretation:

Though brown spongy matter<sup>163</sup> was observable in several, actually in one hole, No.6, which had been sealed on the surface by a large stone, the remains of decayed wood, recognisable by its fibrous character, were still visible. (Curle 1921, 90)

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<sup>163</sup> This refers to decomposed organic matter that still retains some structural integrity, in this instance probably the more resistant lignin fibres of the original wooden post.



It must be accepted that an hiatus occurred in the use of the monument between the abandonment of the internal structure with its consequent decay beneath the resurfaced interior and its new use.

Curle's excavation of the remnant *in situ* soil mass (9ft x 7ft [in area] x 4ft [deep]: i.e. 2.74x2.13x1.22 or 7.12 m<sup>3</sup>) led him to conclude that:

The mass of soil showed no definite stratification, but we proceeded to remove it in horizontal layers from the top, noting any peculiar features that presented themselves. Throughout there were remains of numerous fires in the shape of charcoal and peat ash, showing that there had at all times been shelter here for the fugitive and the vagrant. (Curle 1921, 88)

The thickness of the soil deposit is hard to explain. From the published description, it does not seem like a development *in situ*, but a gradual process of introduction of material to the garth. It is possible, if improbable, that it was a regolith formed from decomposed stone. More probably it was introduced to the garth and prompts the speculation that the abandoned broch was used like a Shetland planticu; an enclosed bed used for seedlings or to protect vegetables from livestock, but one would expect reports of a higher humus content. The variable heights of the hearths found within it would be explained by the intermittent addition of soils.

This set of deposits contained little artefactual material and its lack of stratification points to a gradually and progressively deepening A-horizon, a process consistent with its sheltered and protected location in the garth. Thus, to the hiatus required for the rotting away of the post hole structure, it is necessary to add a duration for the development of the deposits and their intermittent inclusion of hearths made by humans temporarily sheltering in the monument. MacKie's quantitatively different habitations of the tower's tacitly acknowledges this change (Mackie 2007, 860). It is safe to conclude that a significant interval, measured at least in decades and possibly as more than a century was required for the formation of this deposit.

The post hole setting within Dun Troddan is treated here as anomalous to the RSM masonry broch in part because the observation of post holes in broch excavations

remains a rarity. That said, MacKie has frequently noted that the levels at which excavation has ceased are rarely the primary floor levels of the broch (see accounts of Gurness and Midhowe in Chapter 6, for examples). Fojut, conversely argues that while some 20 brochs have been competently excavated to their bases, only Dun Troddan, and Leckie have evidenced sufficient postholes to be considered, however unconvincingly, as concentric post settings<sup>164</sup>. The post holes at Scalloway and Clickhimin form short arcs close to the inner wallface (Fojut 2005b, 192-3). Thus, while post hole settings have been considered standard canonical features of SM2012 they and the architectural mezzanine superstructure to which they have given rise, must be dismissed as canonical structural elements of the RSM.

### **Towards a site biography**

The broch of Dun Troddan was a largely intact monument in the early eighteenth century (Gordon 1726) but was greatly reduced and surrounded by a 1.5 m depth of debris, whilst containing some 1.2 m thereof in the garth when it was emptied and cleaned up by the Office of Works just prior to 1920. Curle's account of his investigations, although not of the standard now common, is logically and clearly expressed (Curle 1921). MacKie's interpretation of these early records (MacKie 2007b) reflects the strong influence of the paradigm within which Euan has worked over the past four decades.

The monument at Dun Troddan is clearly RSM canonical in its surviving form and lacks the later modifications displayed in the Eastern and Northern brochs. Dun Troddan has no obvious external settlement structures set close to it and apart from the small fires, isolated in time and spatial location within the broch sediments, no evidence of substantial non-canonical structures within the broch, if the post hole structure be omitted. Curle is no doubt correct in identifying the latter as evidence of episodic and temporary use of the broch interior by 'the fugitive and the vagrant'

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<sup>164</sup> Ironically the notionally non-circular semi-broch at Rhiroy also contained a set of post holes that form a roughly circular setting. The postholes at Buchlyvie and Carn Liath are associated with pre-broch structures.

Diffuse and sometimes tenuous evidence for localised structural failures and repairs within the broch masonry have been noted above. The hypothesis offered here is that a truly canonical RSM broch structure was built and failed structurally in the area of the entrance and locally in the area of the stacked voids. These failures were remedied and the tectonics of the structure were restored in a renewed canonical fabric. No artefacts associated with these activities have been identified.

Either as part of the primary build or, and more probably, following abandonment of the refurbished structure, a stony soil horizon formed over the floor of the garth space and deepened with time. Through this, arcs of post holes were dug in a curvilinear but not circular setting and not concentric with the broch's centre. A freestanding hut, or a hut that relied on the scarcements for its eaves support was then constructed, used, abandoned and rotted away at ground level. The post stumps surviving within the post holes that were then buried under the progressively deepening sediments which excluded earthworms from the post pipes and facilitated the preservation of structured humic matter in the pipes, and indeed of identifiable rotted wood in Post Hole 6. The suggestion that the wooden posts were removed is inconsistent with this clear excavated evidence and is rejected here.

Curle's suggestion that the paucity of artefacts indicated short duration and sporadic use of the broch is well made and while MacKie's response that such material was lost under unskilled removal of the deposits prior to Curle's arrival, nonetheless, such removal elsewhere has not precluded the recovery of artefactual material, even if only the stone fraction. Tress Barry's perfectly awful excavations in Caithness yielded significant volumes of artefactual debris, for example. On balance, it is argued that the absence of evidence here probably indicates a real evidence of absence.

The original function of the broch remains unknowable from the evidence at Dun Troddan and its subsequent functions seem to have been little more than use as a temporary shelter at irregular intervals. This is consonant with the paucity of artefacts. It might be speculated that, whatever its original function, the construction of the larger broch a short walk further down the valley precluded the reuse of Dun

Troddan in any more substantive role, but the absence of artefactual debris from Dun Telve it also merely relocates the problem.

The construction dates of these brochs remains unknown, and are likely to remain so for the foreseeable future.

### **Canonicity and Mutability at Dun Troddan**

Dun Troddan was built as a canonical broch and despite some significant structural failure and repair cycles, remained a canonical broch preserving the tectonics of the original structure throughout its existence.

### **The broch towers of Scotland**

The case studies have not proved contraindicative of the RSM hypothesis and indeed, the use of the RSM helps to clarify and interpret features, like the relict stacked voids or the mid-level scarcements, that had previously been treated as anomalous features of the original build. More significantly it has indicated a relationship between mid-height scarcements, slapped out high entrances and loss of passage lintels as all relating to rising levels of collapse and rebuilt structures within and outwith the garth.

Between the brochs considered in Chapters 6 & 7 above, and the domical grass covered mounds of the majority of broch monuments there exists a gradient of monuments with observable features. Brief reports on each have been written for this study, but space does not allow their inclusion in main text. As exemplars, a range of these have been included in *Appendix 6.1*. For the remainder of the putative broch towers, a simple tabulation of the relevant features is presented below in Tables 7.3a to d (and in spreadsheet form in Appendix 7.1). The observed diagnostic attributes were selected for their relevance to the structural composition of the monument, considered as an RSM broch. Table 7.1 lists the categories of attribute selected for observation.

Amongst these structural parameters, greatest weight was placed on the entrance configuration and the stacked void attributes because they form a necessary and sufficient structural response to the structural challenge posed by piercing the high

walls of the broch. However, the diagnostic entrance furniture of doorjambs, bolt hole and receiver are afforded little weight as they are commonly observed in Duns also (MacKie 2002, 2). The gross form was next in its power to influence and then the presence of stairways and upper galleries. Obviously brochs that survive as towers, in fact or by reliable record, are automatically identified as broch towers.

Stacked voids, in relict configurations, and other internal features were variously significant. It is interesting that the use of panels of pinnings between larger building stones and of thin slabs to level hard-rock blocks are only found in broch-like structures, and it is argued here, only in broch towers, because of their contribution to the resolution of circumferential forces around the built walls. Thus, these are compelling evidence for broch tower construction. Secondary structures within and around brochs provide some support for the RSM hypothesis because they confirm

Structural Parameters	Code
Entrance compression	EC
Gross Form	F
Galleries	G
Internal Fixtures	I
Masonry	M
Secondary inserts	S
Stairways	St
Historical Records	H
Precision of measurements	Me

patterns of decomposition diagnostic of RSM broch towers and evidence the availability of masses of building stone on the site.

**Table 7.1 Structural categories of attributes selected for observation**

The specific attributes recorded are those listed in Table 7.2 and were selected for their ability to identify the management of the dead load of a tower monument. These attributes have no structural function in smaller buildings and it is likely that their significant building costs would militate against their inclusion in anything less than a tower. Some, like the external batter of the outer wallface, have an implicit aesthetic while others, like the differentiation of the entrance passage lintels, were not easily visible, or perhaps not appreciable, once the monument was built. Their strongest aesthetic principles are those of a critically well engineered structure, albeit one that was built close to the limits of what was possible with the prevailing

construction technology and in consequence they match form and function in an aesthetically or intellectually appealing manner to the modern mind.

**Table 7.2 Incidence of the most significant attributes**

Structural Parameter	Diagnostic attribute	Incidence
EC	Corbelled/Lintelled chamber over the outer passage	33
EC	Differentiation of entrance lintels	18
EC	Stacked void over the inner passage	24
F	Batter angle	
F	Extant Tower	12
F	Inner wall orthogonally circular	27
F	Inner wall vertical or near vertical	
F	Internal radius	
F	Outer wall battered	
F	Outer wall circular in plan	
F	Wall thickness s Internal Radius	
G	Galleries above first level	21
G	Galleries at first level	66
G	Galleries at ground level (1 to 5)	
I	Corbelled cells at ground level	
I	Lintelled cells at ground level	
I	Scarcement at entrance lintel level	
I	Scarcement at high level	
I	Scarcement at mid-level	
I	Typical entrance furniture	
I	Stacked void over stairway entrance	19
I	Relict stacked Voids	19
M	Levelling slabs	2
M	Pinnings between building stones	17
S	Inner lining wall	
St	Stairways higher	7
St	Stairways ... 1/2	12
St	Stairways ... 2/3	9
Metadata entries		
H	Known from historical records only	
Me	Precision of r	

The frequency of occurrence of the main (highlighted) diagnostics is listed in the right hand column of Table 7.2.

These amount to 305 observations of primary diagnostics from a total of 710 observations made, or 22%.

Given the small sample size, the absence of replicate samples, and the poor preservation of the majority of

monuments, it was judged inadvisable to postulate a fixed priority of attributes in order of their frequency as Simões *et al* have done in establishing an index of vulnerability to earthquake damage for structures in Lisbon (Simões, Bento *et al.* 2016, 1514-5; basing their work on the earlier studies of Vicente, Parodi *et al.* 2011). Each broch must be assessed against the diagnostics set out here on its own merits before a determination of its canonicity with the RSM can be concluded.

### **Coding for the Attribute Tables (7.3a to 7.3d)**

The attribute tables list brochs along the top and attributes down the side. The cell entries are coded observations of the diagnostics of the monument. Simple listing of diagnostic attributes by presence or absence could not provide a meaningful test of the RSM hypothesis because apart from the dozen or so emptied brochs it is not possible on most sites to see the majority of the attributes, or even the contexts in which they are expected to occur. A blank table-cell therefore means that the observation could not be made. It specifically does not mean that the absence of the

attribute in question could be confirmed, merely that the context for its observation did not exist or could not be seen because, for example, it was buried under debris or occluded by secondary or later constructions or lost to decomposition.

The observed presence of an attribute is denoted by the use of  $\text{-P}\emptyset$ . If the context in which the attribute should appear could be observed, but the feature was not observed this is indicated by  $\text{-C}\emptyset$  and is a contraindication for the hypothesis under test. Thus, for example, if the inner wall at the height of the entrance passage lintels could be seen but a scarcement could not be seen, this would be coded  $\text{-C}\emptyset$  for the scarcement attribute.

Subscripted  $\text{-h}\emptyset$  is used to indicate that credible historical records exist for the presence of an attribute that cannot now be observed;  $\text{Ph}$  indicates historically attested presence. The code  $\text{-P}?\emptyset$  is used to indicate the writer's uncertainty in the observation and may be read as 'present on the balance of probabilities'. Where it seemed legitimate to do so, the presence of a given attribute was deduced from the surviving indications and recorded as  $\text{-D}\emptyset$ . Typical examples include the deduction that a cell existed above the broch's entrance from the configuration of the surrounding masonry build, or the presence of a stair from ground to first level is deduced from the presence of a gallery at the first floor level. The code  $\text{-AC}\emptyset$  was used to record instances in which an attribute is present but so masked or modified that it is apparently contraindicated: this was commonest in heavily conserved remains.

The only metrical datum presented is the internal radius (r) where this was available. The reliability of the measurement is indicated in the  $\text{-Precision of r}\emptyset$  attribute which may express a standard deviation of the measurement ( $\pm\emptyset\emptyset$  in m);  $\text{-AVG}\emptyset$  indicates that it is an average of a small number of measurements and thus less reliable and  $\text{-UNREL}\emptyset$  records should not be relied upon. A single now completely destroyed monument (Allt na Meirle) is included from existing records because they seem reliable.

The order in which the brochs are listed in these tables places the broch with the highest incidence of competent observations on the left, lowest on the right.

Similarly, the order in which the attributes are set is highest incidence at the top ranging to lowest at the bottom. This makes it a little difficult to compare attribute incidence across the regional divisions and therefore a further table is provided that juxtaposes the order of attributes by area (Table 7.4).



Table 7.3a Western broch towers

Western brochs	Dun Telve	Dun Troddan	Dun Beag	Dun nan Gall	Dun Mor Vul	Dun Osdale	Dun Boreraig	An Sean Chaisteal	Dun Aisgain	Dun Colbost	Dun Hallin	Dun Borodale	Dun Borrafiach	Dun Sleadale	Dun Suladale	Dun Bhoraraig	Dun Arkaig	An Sean Dun	Diagnostics incidence
Galleries at first level	P	P	Dh	P	P	P	P	P?		P		P?	P	P	P?		P	P?	15
Internal radius	4.92	4.28	5.39	5.80	4.91	5.16	5.07	4.04		4.80	5.49		4.95	5.81		6.85	4.23	4.50	15
Precision of r	± 0.02	±0.03	± 0.05	Avg	Avg	± 0.06	±0.054	Avg			unrel		Avg	Avg					
Wall thickness ≤ Internal Radius	P	C	P	P	P	P	P	P?	P	P			P		P		P		13
Scarcement at entrance lintel level	P	P?	P?	P	P	P	P		P		P	P				P/Ph		P	12
Typical entrance furniture	P	P	P	P	P			P	P			P	P	C	P				11
Galleries at ground level (1 to 5)	P	P	P			D				P	P	P		P	P		P		10
Inner wall orthogonally circular	P	P	P	C	D	P	P						C			P			9
Outer wall battered	P	P	P						P	P	P			P	P				8
Corbelled cells at ground level			P		D	P	P								P	P			6
Lintelled cells at ground level	P	P			P					P	P						P		6
Differentiation of entrance lintels	P/Ph			P			P	P	P	P									6

<b>Western brochs</b>	Dun Telve	Dun Troddan	Dun Beag	Dun nan Gall	Dun Mor Vaul	Dun Osdale	Dun Boreraig	An Sean Chaisteal	Dun Aisgain	Dun Colbost	Dun Hallin	Dun Borodale	Dun Borrafiach	Dun Sleadale	Dun Suladale	Dun Bhoraraig	Dun Arkaig	An Sean Dun	Diagnostics incidence
Stairways... 1/2	P	P	P	P		D					P								6
Corbelled/Lintelled chamber over the outer passage	D			P?				D	C				D			D			6
Galleries above first level	P	P	Dh						P			H							5
Inner wall vertical or near vertical	AC	P	P	P	P														5
Outer wall circular in plan	C	P	C									C							4
Pinnings between building stones	P	P	P																3
Relict stacked Voids	P	P		P?															3
Extant Tower	P	P																	2
Levelling slabs			P	P															2
Stairways... 2/3	Ph	Ph																	2
Stacked void over stairway entrance	P	P																	2
Inner lining wall																			0
Stacked void over the inner passage	P	P																	2

<b>Western brochs</b>	Dun Telve	Dun Troddan	Dun Beag	Dun nan Gall	Dun Mor Vul	Dun Osdale	Dun Boreraig	An Sean Chaisteal	Dun Aisgain	Dun Colbost	Dun Hallin	Dun Borodale	Dun Borrafiach	Dun Sleadale	Dun Suladale	Dun Bhoraraig	Dun Arkaig	An Sean Dun	Diagnostics incidence
Scarcement at high level	P																		1
Stairways higher	C																		1
Scarcement at mid-level																			0
Batter angle																			0
Historical records only																			
Total data points per site	24	20	16	13	10	9	8	7	7	7	7	7	6	6	6	5	5	3	155

Table 7.3b Broch towers of the Outer Hebridean

Outer Hebridean brochs	33 Dun Carloway	5 Traigh na Berie	67 Loch an Duna	48 Dun an Sticir	53 Dun Vulan	51 Dun Torcuill	27 Dun Baravat	Diagnostics Incidence
<b>Diagnostics</b>								
Stairways... 1/2	P	P	P	D	P	P	P	7
Galleries at first level	P	P	P	P?	P	P		6
Precision of r	± 0.07	AVG	AVG	UNREL	AVG	OVAL		6
Galleries at ground level (1 to 5)	P	P	Ph	P		Ph	P	6
Internal radius	3.66	5.22	4.58	6.1	5.25			5
Typical entrance furniture	P	P?	P?		P?		P	5
Corbelled/Lintelled chamber over the outer passage	Ph	P	Ph	P	P			5
Inner wall orthogonally circular	P	AC	C			AC	P	5
Wall thickness ≤ Internal Radius	P	P	P?			P		4
Scarcement at entrance lintel level	C	P	AC		P			4
Lintelled cells at ground level	P	P		P				3
Stacked void over the inner passage	Ph	P?	D					3
Outer wall battered	P		P	P				3
Relict stacked Voids	P		P		P?			3
Outer wall circular in plan	C	C					C	3
Corbelled cells at ground level	P		Ph					2

Outer Hebridean brochs	33 Dun Carloway	5 Traigh na Berie	67 Loch an Duna	48 Dun an Sticir	53 Dun Vulcan	51 Dun Torcuill	27 Dun Baravat	Diagnostics Incidence
<b>Diagnostics</b>								
Stacked void over stairway entrance	Ph	P?						2
Differentiation of entrance lintels	Ph	P						2
Scarcement at mid-level	P		P?					2
Galleries above first level	P							1
Inner wall vertical or near vertical	P							1
Inner lining wall		P						1
Pinnings between building stones	P							1
Extant Tower	P							1
Stairways... 2/3		D						1
Batter angle	11.31							1
Scarcement at high level	C							1
Stairways higher	AC							1
Historical records only								0
Levelling slabs								0
Total data points per site	26	17	15	8	8	6	5	85

Table 7.3c Broch towers of Orkney and Shetland

Orkney and Shetland brochs	Broch of Redland	Newark	Midhowe	Knowe of Burreistae	Ings Howe	Gurness	Hillock of Burray	Jarishof	Broch of Borwick	East broch of Burray	Old Scatness	Mousa	Houbie	Levenwick	Eastshore, Brough Head	Holm of Coppister	Culswick	Burra Ness	Burriland	Clickhimin	Diagnostics incidence
Galleries above first level	P	P?		P	Ph	Ph	Ph	P					Ph								8
Stacked void over stairway entrance	AC	P	P	P	Ph	P	Ph		D												8
Corbelled cells at ground level	P	Ps?		P	P	P	P?					P									7
Inner lining wall/Secondary structure	P	P	P?	P			P		P	P											7
Relict stacked Voids	P	P	P	P		P		P?		P											7
Stairways... 2/3	P	P	P	C	D		Ph	D													7
Galleries at ground level (1 to 5)	P		P		P				D		P		D								6
Inner wall vertical or near vertical	AC	P?	AC	P?		P					P										6
Pinnings between building stones	P	P	P	P	?						P?										6
Scarcement at mid-level	P	?	P	P	?					P											6
Extant Tower	P		P?	P	Ph			Ph					Ph								6

Orkney and Shetland brochs	Broch of Redland	Newark	Midhowe	Knowe of Burristae	ingshowe	Gurness	Hillock of Burraghston	Jarlishof	Broch of Borwick	East broch of Burray	Old Scatness	Mousa	Houbie	Levenwick	Eastshore, Brough Head	Holm of Coppister	Culswick	Burra Ness	Burraland	Clickhimin	Diagnostics incidence
Differentiation of entrance lintels	P	P	P		P	P															5
Lintelled cells at ground level	P		P				Ph			P											4
Inner wall orthogonally circular	P	P?	C			P															4
Outer wall circular in plan	P	?	P								P?										4
Stairways higher	P?			P			?	D													4
Batter angle	12.67							5													2
Scarcement at high level	D	?																			2
Historical records only																					0
Levelling slabs																					0
Total data points per site	26	23	22	21	18	17	14	11	11	10	9	6	4	4	3	3	2	1	1	1	207

Table 7.3d Northern Brochs, Part I

Northern brochs Part 1	Caisteal Grugaig	Clachtoll	Clachtoll	Backies	Yarrows	Carn Liath	Kintradwell	Dunbeath	Carrol	Dun Dornaigil	Ousedale Burn	Caisteal na Coille	Dun Creagach	Dail Langwell
Diagnostics														
Galleries at first level	P	P	P	P	Ph	P	P	P?	P	P	D	P	P?	P
Internal radius	4.69	4.78	4.78	4.13	4.86	5.10	4.72	4.24	4.69	4.13	3.33	3.38	4.73	4.73
Precision of r	± 0,06	± 0,08	± 0,08	± 0,07	± 0,06	± 0,09	± 0,07	± 0,05	± 0,06	± 0,07	± 0,05	± 0,12		
Wall thickness ≤ Internal Radius	P	P	P	C	P	C	P	P?	P		P	C		C
Stairways... 1/2	P	P?	P?	P	P	P	P	P?	P	P	P		D	
Corbelled cells at ground level	P	P	P				P	P	P	P	P	P		P
Typical entrance furniture	P	P	P	P	P	Ph	P	P	P		P	P		P
Lintelled cells at ground level				P	P	P	P	P		Ph	P?		P?	
Galleries at ground level (1 to 5)	P	P	P	P	P				P	Ph			P?	



Northern brochs Part 1	Caisteal Grugaig	Clachtoll	Clachtoll	Backies	Yarrows	Carn Liath	Kintradwell	Dunbeath	Carrol	Dun Dornaigil	Ousedale Burn	Caisteal na Coille	Dun Creagach	Dail Langwell
Diagnostics														
Corbelled/Lintelled chamber over the outer passage	P	P	P	P	P	D	P		P	P	P	P	P	
Scarcement at entrance lintel level	P	P	P	P	C	?	C	AC	C		P			
Stacked void over the inner passage	P	D	D	P	P	Ph	Ph		P	Ph	P	D		
Inner wall orthogonally circular		P	P	P	P	?	P		P					
Outer wall battered	P	P	P			P	P	P	P	P			P	
Galleries above first level	P				D	Ph		P		P			P	
Inner wall vertical or near vertical		P	P	P		C	P	P?						
Inner lining wall		P	P	P	P	P	P							
Pinnings between building stones	P	P	P			P		P	P?			P		
Stacked void over stairway entrance	P?			P	P		Ph				P		P	P?

Northern brochs Part 1	Caisteal Grugaig	Clachtoll	Clachtoll	Backies	Yarrows	Carn Liath	Kintradwell	Dunbeath	Carrol	Dun Dornaigil	Ousedale Burn	Caisteal na Coille	Dun Cragach	Dail Langwell
Diagnostics														
Differentiation of entrance lintels	P	P	P								P	P		
Extant Tower	Ph									P				
Scarcement at mid-level								P				P?		
Stairways... 2/3	P				P									
Outer wall circular in plan				P?										
Historical records only														
Batter angle										15				
Stairways higher	D													
Levelling slabs														
Scarcement at high level														
Total data points per site	19	17	17	17	16	16	16	15	14	14	13	12	10	7

Table 7.3d Northern Brochs Part II

Northern Brochs Part II	Carn Bran	Feranach	Sallachaidh	Dun Maigh	Langdale	Allt na Meirle	East Kinnauld 1	Grummore	Burgh Ruadh	Watenan North	Alltbreac	Carn Merik	Knock Glass	Dun Alasaig	Diagnosics incidence Parts 1 and 2
Diagnosics															
Galleries at first level	P	P	AC	P	P	P	P	Ph	P	P?	P	P	P		27
Internal radius		5,5	4.95		4.58			4.50		6.00					19
Precision of r															12
Wall thickness $\leq$ Internal Radius		P	P?		P			P							16
Stairways... 1/2	P		P	P					P						16
Corbelled cells at ground level		P	P?	P	P		P								15
Typical entrance furniture	P			P	Ph										15
Lintelled cells at ground level	P?	P		P			P			P?					13
Galleries at ground level (1 to 5)	P					P		P	P		P				13
Corbelled/Lintelled chamber over the outer passage															12

Northern Brochs Part II	Carn Bran	Feranach	Sallachaidh	Dun Maigh	Langdale	Allt na Meirle	East Kinnauld 1	Grummore	Burgh Ruadh	Watenan North	Alltbreac	Carn Merk	Knock Glass	Dun Alasaig	Diagnostics incidence Parts 1 and 2
Diagnostics															
Scarcement at entrance lintel level	Ph						C								12
Stacked void over the inner passage															11
Inner wall orthogonally circular		P?													9
Outer wall battered															9
Galleries above first level			D												7
Inner wall vertical or near vertical															6
Inner lining wall															6
Pinnings between building stones															7
Stacked void over stairway entrance															7
Relict stacked Voids						D									6

Northern Brochs Part II	Carn Bran	Feranach	Sallachaidh	Dun Maigh	Langdale	Allt na Meirle	East Kinnauld 1	Grummore	Burgh Ruadh	Watenan North	Alltbreac	Carn Merk	Knock Glass	Dun Alasaig	Diagnosics incidence Parts 1 and 2
Diagnosics															
Differentiation of entrance lintels															5
Extant Tower														Ph	3
Scarcement at mid-level															2
Stairways... 2/3															2
Outer wall circular in plan															1
Historical records only						Ph									1
Batter angle															1
Stairways higher															1
Levelling slabs															0
Scarcement at high level															0
Total data points per site	6	6	6	5	5	4	4	4	3	3	2	1	1	1	254

**Table 7.4 The regional frequency of observed diagnostics. WB denotes Western Brochs, OHB Outer Hebridean Brochs, NB Northern Brochs and O&SB the brochs of Orkney and Shetland. The diagnostics are listed in alphabetical order and the numerical values are the ordinal values for the attributes, e.g. 1 indicates the commonest attribute in the region and 30 the least common. The blue text can be ignored: these are metadata entries.**

<b>Diagnostic attribute</b>	<b>WB</b>	<b>OHB</b>	<b>NB</b>	<b>O&amp;SB</b>
Batter angle	29	26	27	27
Corbelled cells at ground level	10	16	6	13
Corbelled/Lintelled chamber over the outer passage	14	7	10	10
Differentiation of entrance lintels	12	18	21	22
Extant Tower	20	24	23	21
Galleries above first level	15	20	15	11
Galleries at first level	1	2	1	1
Galleries at ground level (1 to 5)	7	4	9	17
Historical records only	30	29	26	29
Inner lining wall	24	22	17	14
Inner wall orthogonally circular	8	8	13	24
Inner wall vertical or near vertical	16	21	16	18
Internal radius	2	5	2	2
Levelling slabs	21	30	28	30
Lintelled cells at ground level	11	11	8	23
Outer wall battered	9	13	14	6
Outer wall circular in plan	17	15	24	25
Pinnings between building stones	18	23	18	19
Precision of r	3	3	3	7
Relict stacked Voids	19	14	20	15
Scarcement at entrance lintel level	5	10	11	4
Scarcement at high level	26	27	29	28
Scarcement at mid-level	28	19	22	20
Stacked void over stairway entrance	23	17	19	12
Stacked void over the inner passage	25	12	12	9
Stairways higher	27	28	30	26
Stairways... 1/2	13	1	5	8
Stairways... 2/3	22	25	25	16
Typical entrance furniture	6	6	7	5
Wall thickness ≤ Internal Radius	4	9	4	3

## The regional groups

### Western brochs

Some eighteen brochs have been identified as broch towers in the Western Broch group. The tabulation of diagnostic attributes (Table 7.3a) yields 540 potential observations of which only 155 or 29% could actually be made. Of the 155 observable diagnostics, 9 were contraindicative for the RSM hypothesis, and 146 did not contradict it. Three of the contraindications arose because the outer wall was not circular and three because the inner wall was not circular. At Dun Borodale, neither was circular and this is sufficiently contraindicative that Borodale is not considered a broch tower for this study, being at best an anomalous example. The other non-circular inner wall is at Dun na Gall, but it is probable that this is an error of measurement rather than a real contraindication. Sufficient of the upper storeys of Dun Telve and Dun Trodden survive and are recorded historically to suggest that no stairway existed above the second storey. This is recorded as a contraindication but in reality, it supports the RSM which rejects higher stairways<sup>165</sup>.

On the raw numbers, then, the observed and historical data does not reject the hypothesis. However, the data is not evenly spread and, for example the three rightmost brochs have only 5, 5 and 3 observable diagnostics. Dun Boraraig, which lacks the common gallery at first floor level nonetheless exhibits in the masonry of its entrance the likelihood that it had a cell above the outer entrance passage, which is strongly indicative of a tower building. It is harder to defend the inclusion of Dun Arkaig and An Sean Dun in the catalogue of broch towers and perhaps these are best considered as -possible brochsø while the monuments in the body of the table range from certain towers on the left to probable towers as we move right, with the degrees of probability being high but variable.

### Outer Hebridean Brochs

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<sup>165</sup> This logical reversal arises because setting the attribute at -absence of upper galleriesø could begin a slide into the use of negative evidence.

Some seven brochs have been identified as broch towers in the Hebridean group. The tabulation of diagnostic attributes (Table 7.3b) yields 210 potential observations of which only 85 or 40% could actually be made. Of the 85 observable diagnostics, 6 were contraindicative for the RSM hypothesis, and 79 did not contradict it<sup>166</sup>. Three of the contraindications relate to non-circularity of the outer wall and have low evidential value for the reasons explained in Chapter 3, Circularity. The inner wallface at Loch an Duna may not be circular and there does not appear to have been a high level scarcement at Dun Carloway, but this may be mistaken. At Carloway also, the scarcement is not set at the entrance lintel level. However, as the case study demonstrates, Dun Carloway has undergone several structural failures (Chapter 7) and less weight should be given to this observation.

On the raw numbers, 93% of the observations failed to reject the RSM hypothesis. Dun Bharabhat and Dun Torcuill should be considered as probable broch towers on the balance of the evidence, the others being accepted as broch towers, compatible with the RSM hypothesis.

### **Northern brochs**

Some twenty-eight brochs have been identified as possible broch towers in the North Mainland broch group. The tabulation of diagnostic attributes (Table 7.3c Parts I and II) yields 540 potential observations of which only 254 or 30% could actually be made. Some 9 of the 254 observable diagnostics were contraindicative for the RSM hypothesis, and 245 did not contraindicate it. Four of the contraindications arose in respect of wall thickness and the difficulties already noted in getting reliable outer wall data suggests that these contraindications should not be accorded too much weight. In four other cases, no scarcement was noted at the level of the entrance passage lintels. Of these the brochs of Yarrows and Kintradwell have been extensively remodelled in antiquity and the ambiguous case of Carn Liath has also suffered from overactive conservation and maintenance (See Appendix 6.1). The

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<sup>166</sup> This includes 4 apparent contraindications that on examination proved not to be the case.



contraindicative inner wall verticality, or lack of, at Carn Liath is similarly an artefact of ancient rebuilding and modern mismanagement.

On the raw numbers, 96% of the observations failed to reject the RSM hypothesis. The brochs of Carn Merk, Knock Glass and Dun Alasaig have been identified as broch towers largely because they have galleries at their first floor levels. Whilst not utterly compelling, this is a strong indication and in these cases the remains could be further explored to clarify the situation. They have been retained with the others in this table as broch towers. Similarly, the Alltbreac broch has an apparently weak claim, but reference to Appendix Alltbreac provides a stronger justification for its inclusion in the group.

### **Orkney and Shetland brochs**

Some twenty brochs have been identified as broch towers in the Orkney and Shetland broch group from populations of 114 and 109 respectively<sup>167</sup>. The tabulation of diagnostic attributes (Table 7.3c) yields 600 potential observations of which only 207 or 35% could actually be made. Of the 207 observable diagnostics, 10 were contraindicative for the RSM hypothesis, and 197 did not contradict it. Five of the contraindications arose in respect of scarcements at the height of the entrance passage lintels. This includes those at Gurness and Midhowe, in which major alterations to the broch structures at several times in antiquity have masked or removed the scarcement ledge, while at East Burray, the evidence is ambiguous because of the condition of the monument. Jarlshof is scarcely recognisable as a broch and has undergone major modifications in antiquity and unsympathetic conservation in more recent times. The absence of the ground floor to the first floor (Stairway 1/2) has been noted at Gurness and Midhowe, in both of which it is now argued an original stairway was blocked off following partial collapse of the structure (Chapter 6). Similarly, the inner wall is recorded as non-circular but laser scan survey shows that it was originally circular and remains so at ground level, but

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<sup>167</sup> These are the totals of brochs and probable brochs listed in the NMRS database. LSMRs sometimes list additional sites, with varying degrees of confidence.

the upper wall has been distorted by the broch collapse (see Structural tomography in Chapter 5).

Modifications, probably including some episodes of collapse are responsible for the current condition of Clickhimin (see again Chapter 6 and more particularly Smith Forthcoming, for details of modern interventions and their impacts on interpretation of this monument). It is argued here (Chapter 6) that Clickhimin was originally constructed as a canonical broch tower and underwent a series of natural and anthropic modifications to reach its current condition. Smith's observations and analysis of the Clickhimin biography clearly prevail over MacKie's in this instance and is founded upon here in conjunction with our own observations to conclude that Clickhimin was an RSM broch.

### All brochs

Table 7.3e draws together all of the regional data in a population study of the diagnostic attributes. It is too large to present in these pages and is appended<sup>168</sup> in Appendix 7.1 as a spreadsheet 'Global Diagnostics' on the attached CD-Rom.

Some seventy-three broch towers have been examined in this study. The tabulation of all diagnostic attributes (Table 7.3e) yields 2190 potential observations of which 710 or 32% could actually be made. Of the 710 observable diagnostics, 33 were contraindicative for the RSM hypothesis, and 677 did not contradict it, i.e. a 4.65% contraindication. It is noticeable that with one exception, brochs with more than a single contraindication have been excavated and conserved in the past century and some of these contraindications relate to unsympathetic conservation. The exception is Dun Borodale which has a very eccentric plan so that neither its inner nor outer walls are circular. This monument must be dismissed as a broch tower because it is directly and substantively contraindicative of a defining attribute of the broch tower, its circularity.

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<sup>168</sup> It comprises the combination of Tables 7.3a to d, presented above, so its absence from the text, while unfortunate is not disastrous.

## Conclusion on the RSM

In Chapter 3 the defining parameters of the broch tower were set out and the RSM form was derived from them as the exemplar canonical broch. In Chapters 6 & 7 the most fully explored and best surviving of the monuments were examined as case studies and the variances from canonicity they demonstrate were shown to result

Galleries at first level	1
Typical entrance furniture	2
Batter angle	3
Internal radius	3
Scarcement at high level	3
Extant Tower	4
Historical records only	4
Precision of r	4
Stairways higher	4
Inner wall vertical or near vertical	5
Pinnings between building stones	5
Relict stacked Voids	6
Wall thickness $\leq$ Internal Radius	6
Corbelled/Lintelled chamber over the outer passage	7
Scarcement at entrance lintel level	7
Outer wall battered	8
Galleries above first level	9
Levelling slabs	9
Scarcement at mid-level	9
Stairways... 2/3	9
Corbelled cells at ground level	10
Differentiation of entrance lintels	10
Inner lining wall	10
Outer wall circular in plan	10
Stacked void over stairway entrance	11
Stairways... 1/2	12
Galleries at ground level (1 to 5)	13
Lintelled cells at ground level	15
Inner wall orthogonally circular	16
Stacked void over the inner passage	16

**Table 7.5 The range of ordinal variation for the observed diagnostic attributes. A value of 10, for example, means that the attribute involved occurred with minimum and maximum ordinal values 10 units apart.**

from structural failures, natural and anthropic, and sequential human reforming of the resultant ruins. In this chapter (Chapter 7) the distribution of observable attributes has been set out. Regionally and globally the observation of diagnostic attributes that are consistent with the RSM compared with those contraindicative of it occur in the ratio 95:5, or 19:1. This cannot be treated as in any sense a proof of the canonicity of the broch towers because these observations, pro and con, are only observable for one third of the possible instances. However, it can be asserted with confidence that the

accessible data does not contradict the hypothesis and moreover, that the hypothesis remains testable by further work in this field. The RSM offered new interpretations of relict features including, for example the Midhowe aumbry, and other secondary or remodelled features like its souterrain. It also offered a more coherent interpretation of the frequency with which broch entrances were modified to

facilitate entry after the interior had filled to above the top of the ground floor level. These new interpretations are coherent, testable and not previously offered and certainly not previously conceived of in the aetiological context of a canonical model with preferred routes to decomposition and reuse. It is therefore assumed from this point onwards that broch towers are canonical forms, built to a standard form that successfully manages the challenges of structural dead loads, a form so constraining of their immediate environments that even in their natural and anthropic decomposition they retain the evidence of their primary structural form.

### **Variable and vernacular**

In Table 7.5, the range of ordinal values of each attribute across the four regional groups have been arranged in order of the differences between their highest incidence and their lowest. Thus, they serve as a proxy record of the stability or febrility of the attribute as a diagnostic. Although 20 of the 30 attributes lie in ordinal ranges of less than 10, high variability is observable in the remaining 10 diagnostics. Taken simplistically, this might encourage the idea that there are regional patterns in broch forms that are contraindicative to the RSM hypothesis and in a general way supportive of a vernacular genesis for the monuments. However, examination of the attributes shows that there is a high degree of autocorrelation between the most variable of them. Thus, for example, variability in the observability of orthogonal circularity and of stacked voids over the inner entrance passage are autocorrelated via the collapsed state of the monument.

It is not possible to conclude from this data that coherent variation in the built form is detectable across the geographical range. Given that the nature and state of monument collapse is more closely correlated with the lithology of the building stone, constrained by the built form, and that the exposure of the remains is correlated with the extent to which they have been stripped out for display or simply as an economic use of stone, the greatest correlates are identifiable as the division between hard-rock built structures and sedimentary stone buildings.

Were the built brochs subject to vernacular variability we should expect harmonic variation across the range of diagnostics considered in geographical groups. These

variations are not present in the data. Thus, there is no support in the data presented in Tables 7.3 to 7.5 for the idea that brochs are vernacular buildings, which are characterised by such variability, and no positive strong contraindication for the RSM hypothesis.

## Chapter 8 The construction of broch towers

### Introduction

As noted in Chapters 6 & 7 the hypothesis that broch towers are canonical structures has not been refuted by the evidence and it has been concluded that broch towers were built to a canonical RSM form over a variation range contained within the internal radii domain 3.5 to 7.5 m and a batter angle domain of 10° to 25°. The built volumes of brochs in the variation range has been tabulated in Table 4.3. Here, accepting their canonicity, the consequences of the built form for their structural integrity, ground loading and paths to decomposition are further considered.

### Resistance of stone to static and dynamic forces

The compression strength of stone, which measures the force required almost to crush it, is in general very high<sup>169</sup>. For sedimentary rock types compression strength values of up to 255 MegaNewtons, (MN/m<sup>2</sup>; or c. 36,980 psi) have been returned<sup>170</sup>. However, this value is very variable, even from a single quarry, and is also influenced by the angular relationship between the load vectors and the bedding planes of sedimentary rock types<sup>171</sup>. In contrast, their flexural strength, i.e. their ability to resist deformation under load, is rarely more than 15 MN/m<sup>2</sup> (2,176 psi)

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<sup>169</sup> One Newton (N) is the force needed to accelerate one kilogram (1 kg) of mass at the rate of one metre per second squared (1m/s<sup>2</sup>). At the ground surface the acceleration due to the force of gravity is c. 9.8 m/s<sup>2</sup> so that 1 kg resting on the ground surface exerts a force of 9.8 N on the ground surface. A kiloNewton (kN) equals 1,000 Newtons (1kN=1,000N) and a MegaNewton is 1,000,000N. The force applied by 1 tonne (1,000 kg) to the ground surface, under gravity alone, is 9,800 N or 9.8kN. Thus also, 1 kN is equivalent to the force generated by roughly 100 kg acting under gravity. The Pascal (Pa) is the pressure created by the application of a force of 1 N operating over 1 m<sup>2</sup>. Thus 1Pa = 1 N/m<sup>2</sup> = 1 kg/m.s<sup>2</sup>, where N is the newton, m is the metre, kg is the kilogram and s is the second. 1 kilopascal (kPa) is equal to 1000 Pa or 1000N/m<sup>2</sup>. The European standard NBN EN (Es 1926) provides details of the standard methods for the measurement of compression strength of stones.

<sup>170</sup> See for examples *Appendix C: Stone and rock properties*, in Geological Society of London, Engineering Geology Special Publications, 1994, 451-70, <http://egsp.lyellcollection.org>

<sup>171</sup> Nonetheless, it has been calculated that in optimum circumstances a column of sandstone would need to be 1.6 km high before it crushed its footings (Zalewski and Allen, 1998, 31).

and their tensile strength lies in the range 4 to 15 MN/m<sup>2</sup>, for greywacke sandstone and considerably less, and in practice more variable, for other sandstones<sup>172</sup>.

Given the variables involved, it is difficult to estimate reliably, the superincumbent load that would flex a lintel and then, given the weakness of stone in tension, break it. Calculations based on the standard formulae and using representative lintel dimensions from extant examples in brochs indicate failure under modest loads; 0.11kN to 3.2 kN for a range of lintel thicknesses and cross sectional form (Cobb 2015, 58)<sup>173</sup>.

It is obvious that many lintels have broken in antiquity. Many of the struts in stacked voids display evidence for vertical displacement of one side of the void relative to the other, breaking or displacing struts (see Figure 163 a, for example). Freshly quarried stone is often flawed, with, for example, hidden cleavage plane weaknesses that are not discoverable on visual inspection but which would reduce the tensile integrity of the stone to near zero. This may explain why erratics that have already survived glacial and or fluvial turbation were generally selected for lintels, stair treads and the like.

The foregoing comments relate to static loads only, but it will be clear that wind imposes substantial forces on broch towers and cycles of freeze and thaw and of use might make a slight contribution. One of the challenges to the fabric at Mousa must be Shetland's exceptional peak wind forces.

Crack-swarms have been noted by the writer at four brochs, initially Thrumster and Clachtoll and latterly at Dunbeath and Dun Fiadhairt. Crack-swarms comprise nested parallel cracking and fracturing of stones in a volume of walling that may also

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<sup>172</sup> In addition, recent Czechoslovak tests of medieval building stone types suggest that both compressive and flexural strengths can be significantly reduced by saturation of the stone, with flexural strength more than halved (Hasnikova 2013, 432-3).

<sup>173</sup> The standard formulae assume constant cross sectional dimensions but with Iron Age stone lintels the variables in each lintel are such that only a practical series of measured tests for a specific configuration should be relied upon in conservation, and these are beyond the scope of this study.

contain interspersed undamaged stones. The bell tower at Monza exhibits similar patterns of fracturing that pierces the full thickness of the brick-built tower wall (Figure 172). It is believed that a combination of compressive forces and vibration



from heavy traffic on the adjacent road have caused this to develop (Valluzzi 2006, 737-8). Vibration is not an obvious threat to brochs most of which are sited far from modern roads or other sources of mechanical vibration.

**Figure 172 Vertical crack swarm in the brick masonry of a tower in the 16th century Cathedral of Monza. The cracks were caused by a combination of compressive overload forces and vibration. Together they slowly widened and deepen the cracks, many of which pierced the full thickness of the wall (after Modena, Valluzzi et al. 2002, Figure 4).**

Following careful down-taking at Thrumster and again at Clachtoll, the writer observed panels of masonry on one or both sides of an entrance passage that exhibited crack-swarms similar to those noted in the masonry of Monza bell tower (Figure 172). Believing that such extensive damage would have required a catastrophic origin<sup>174</sup>, it was initially hypothesised that in their collapse, vertical segments of the broch tower wavered or rotated out of line from their original positions. In consequence, the area of wall masonry bearing the mass in question could be substantially reduced and the pressures on the stable masonry beneath, would locally climb towards infinity, however briefly. At Clachtoll the evidence for a major collapse was compelling (Figure 173) and seemed to verify this operational hypothesis. Distributed unequally through the underlying masonry mass, the forces

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<sup>174</sup> Whilst it may appear that crack swarms have resulted from freeze and thaw actions, the fact that the stones have cracked across rather than along their bedding planes makes this suggestion rather improbable.





**Figure 173** A crack swarm in masonry right of the stacked void over the entrance passage at Clachtoll. Stones 2, 9/10, 11, 6, 7, 14, 15 and 21 were broken when revealed. In the wall core virtually every stone was cracked or broken.

generated by the falling structure would have been sufficient to crack or fragment many stones in the wall (see

Figure 173). The compression forces locally and irregularly exceed the capacity of the *in situ* stones to bear them and crack swarms resulted in which, for example, a given stone might be completely fractured whilst those above or below it would be sound.

Work by Bigoni & Noselli on the modelling of stress percolation in drystone masonry indicates a distribution of vertical fringes of stress that offers a further interpretation. This configuration is illustrated in Figure 174 a & b), based on their work (Bigoni and Noselli 2010, 300, their Fig 1.). Their analysis and interpretation of the observed patterns indicates;

The highly localized stress distribution found within dry masonry walls [analysed] through transmission photo-elasticity is explained both proposing a micromechanical model (based on a form of random cascade transmission of forces between bricks, which includes random coalescence additionally to random branching) and applying a phenomenological description (based on the extreme orthotropy of the equivalent homogeneous material). (Bigoni and Noselli 2010, 300).

The authors note that random or near random branching is accompanied with equivalent recombination that occasionally isolates or strain-free islands within

the stress percolation (ibid, 291). The dark green blocks within the stress field in Figure 174, a & b illustrate examples of such null points.

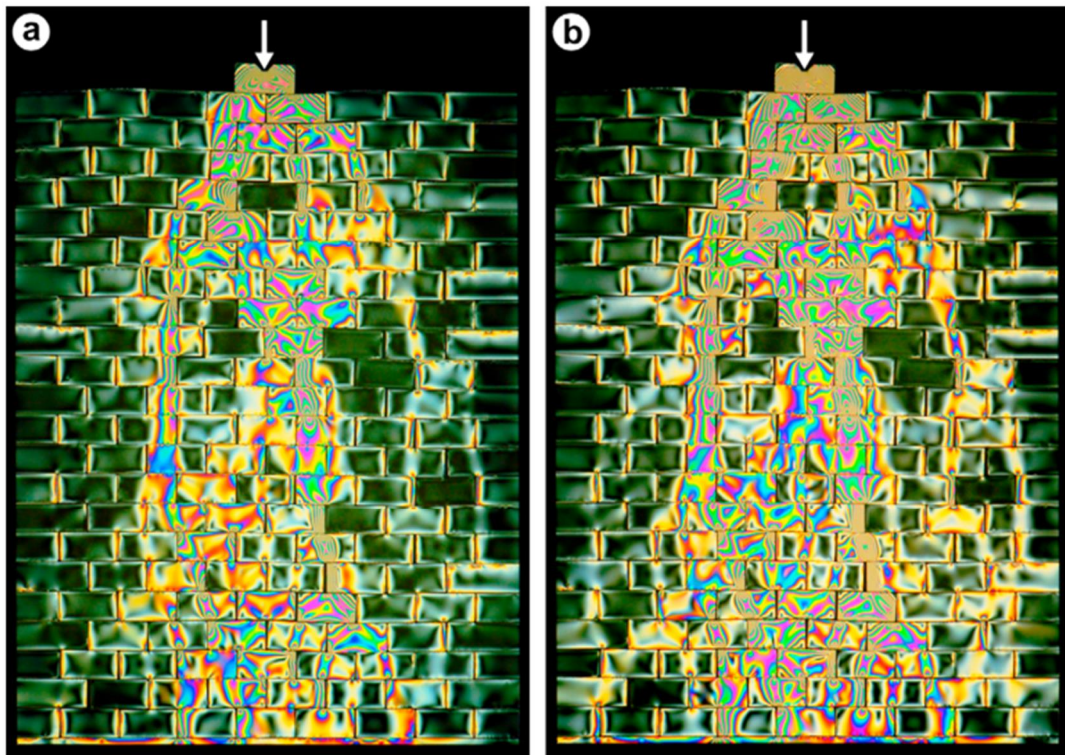


Figure 174 a & b Reproduced from (Bigoni and Noselli 2010, Fig. 6) the stress free blocks are dark green and the scale of stress in the other blocks can be measured from the coloured bands revealed in polarised light. The white arrows denote the applied vertical load: 400 N on the left and 800 N on the right. The material used to make the model is PSM-9, a polycarbonate.

The experimental work by Noselli & Bigoni is based on the use of regular sized and shaped polycarbonate blocks with specific contact configurations, conditions that only persist locally, if at all, on a broch<sup>175</sup>. Nonetheless, it provides a background explanation for patterns of stress fractures that has been observed in brochs<sup>176</sup>. If

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<sup>175</sup> One exception may be the broch of Dun Beag on Skye, the stones of which are remarkably consistent in size and shape.

<sup>176</sup> Broch masonry is also approximately orthotropic. In material science and solid mechanics, orthotropic materials have material properties that differ along three mutually-orthogonal twofold axes of rotational symmetry. They are a subset of anisotropic materials, because their properties change when measured from different directions.

their work can be generalised, it may be argued that crack swarms result from stress percolation, similar to soil creep in its aetiology, given the stress distribution patterns noted by Bigoni and Noselli (2010) and creating ‘masonry creep’. The association of the observed patterns with the sides of entrances at all four of the named sites, where the design stresses are increased by the additional load of the masonry flanking the stacked void, offers some support for this hypothesis.

Whether caused by creep-like processes where strain increases for constant stress and cracking may be cumulative, or by catastrophic failures, it may be concluded that the presence of crack swarms is a positive indicator for the prior existence of loads imposed by a tower, either acting over time or catastrophically. This is a one-way test and the absence of crack swarms clearly does not demonstrate a low construction<sup>177</sup>.

## Subsidence and settlement

Subsidence results when all or part of the ground underlying a structure yields, allowing the buildings footings to sink below the level at which it was constructed. Settlement is the distortion or disruption of parts of a building caused by unequal compression of its foundations, shrinkage of the structure, e.g. in timber structures, or from undue loads applied to the building after its initial construction. The forces generated by static loads of the built mass can be augmented by thermal variation, wind force and traffic vibration, amongst other factors<sup>178</sup>. Prehistoric structures may settle unevenly into variable substrates. Settlement under these circumstances may be minor, appear to halt after an initial settlement, or be effectively undetectable but creep, having been initiated, can continue for centuries.

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<sup>177</sup> Archaeologist should note that this is a one-way test and the absence of crack swarms clearly does not demonstrate a low construction. In addition crack swarms are more likely to be discovered behind fallen stone than within exposed masonry because the damage to the structural integrity of the wall is sufficiently large and extensive to cause rapid loss of exposed masonry.

<sup>178</sup> Modern structures crack and fracture in diagnostic ways where the forces generated by the uneven mass distribution find expression (Holland, M (2012). *Practical guide to diagnosing structural movement in buildings*. Oxford, Wiley-Blackwell., Parts I and III).

-From the beginning of its construction, the Leaning Tower of Pisa<sup>179</sup> had already inclined, due to the non-uniform settlement. This condition became worse due to increase in settlement without additional stress. This phenomenon is known as creep, which is defined as change of strain under constant stress.ø (Badrul 2012, notes to the book)

Differential settlement can result from building across variable substrates and certainly this was the case with several brochs, and is clearly visible at the eroding broch of Eastshore, Shetland (Figure 175 and see Carter et al, 1995, 452-3 for discussion of midden under parts of the broch wall) and excavation at Dun Vulcan revealed that it was built partly on bedrock and partly on sand (see MacKie 2007b, 1117 for discussion).



**Figure 175 Broch at East Shore, Pool of Virkie, Shetland. The inner wall and its scarcement are visible on the right and tumble and collapse near the centre fall away to the foreshore sloping down some 3 m below, to the left. The LHS of the broch had been built on unconsolidated material**

A cleft in the bedrock, probably not wider than 2 m, under the line of the wall at Thrumster had been infilled with small stone rubble and built over with a levelling plinth, but this only presented an isolated challenge to the fabric which made no observable response, see Appendix Thrumster). Weakening or loss of the parts of the lower wall has also been noted, especially in brochs in coastal locations, like Clachtoll and Eastshore and even at non-broch-tower structures like that at St

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<sup>179</sup> Built in three stages, in 1173, 1272 and 1372, the Leaning Tower's continuing settlement was arrested in 1990-2001 and its tilt was reversed by over 2 degrees to its current 5.5 degrees .

Boniface, which collapsed and was rebuilt early in its development history (Lowe 1998).

However, localised subsidence does not necessarily lead to general collapse. This is one important result of experimental work led by Theodossopoulos at the University of Edinburgh's architecture School and of the writer's ongoing experimental work in Caithness. It has been the demonstration that drystone built masonry forms arches over quite significant holes (Figure 176) forced through the inner or outer walls at ground level (Thew, Sutherland *et al.* 2012; Reutter 2012, Gilbertson 2013; Primavesi 2013). These works variously demonstrated that reduction in the substrate of many meters would be required to imperil a broch wall, and that moderate but not insignificant stone loss would arch or bridge over without immediately imperilling the rest of the structure. These results are consonant with field observation and have been applied in the temporary propping of an area of stone loss beneath the south wall at Clachtoll (Theodossopoulos and Cavers 2014). Moreover, steps in the substrate have the potential to form cracks in the masonry above and along the line of the step (Gilbertson 2013 51; Primavesi 2013, 49).

The writer, to explore issues of the stability of the entrance configuration at Clachtoll and the possibility of inserting new entrances through erect broch walls, constructed a 1:1 model of the entrance area and then tried to force a controlled collapse of a thin strip of masonry between the guardcell and the garth (Figure 31) Although the hole was pushed through as far as the guardcell sidewall, which it pierced, the masonry above it bridged or arched over the opening and did not collapse<sup>180</sup>.

However, the optimism of this result must be tempered by the manifest evidence of historical losses and of ongoing masonry distress, e.g. the major cracking of the inner wall at Mousa (

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<sup>180</sup> Its significance for the interpretation of secondary entrances, especially at Thrumster, was very high because either the evidence there indicated that entrance insertion was possible in standing monuments or the monument had been stripped to ground level several times in its biography, and the latter seemed highly improbable.

Figure 74) where no subsidence is detectable. Nonetheless, it is accepted that subsidence alone is unlikely to have triggered failure in otherwise stable broch structures.



**Figure 176**  
**Experimentally induced arching over ‘subsidence’ hollow (Gilbertson 2013, her Figure 41).**

The process of masonry creep, increasing strain for constant stress, is proposed as a causative factor in the formation of crack swarms and cracks in broch masonry. If masonry blocks are built with poor surface to surface contact, and, or, if the use of pinnings or levelling slabs was inadequate in improving their contact areas, the stress on a given block may, with slight settlement in the wall, break across an uneven or isolated point of support. Over time, such settlement flaws could cascade, down and up, fracturing new stones onto which the stresses were then deflected, at first slowly but potentially catastrophically after a time.

Additionally, the failure of internal voids, where such have been sealed off or rebuilt with lower stacking density, could initiate the same cascading creep process on lines that may at first be intermittent (see Bigoni and Noselli 2010 and discussion above) but cumulatively can destabilise the wall involved.

The inner broch wall, densely built with pinnings carefully packed to resist stone movement, would be theoretically capable of resisting circumferential forces up to the compression strength of stone. Movement of the wall inwards would be, again, theoretically, impossible without crushing the stone. Therefore, the wall could not fall under the compression of the outer wall, which its designed counters. However, an inward movement out of the vertical of 100 to 200 mm of the inner wall at the

uppermost gallery floor in a 15 m high broch is sufficient to pull the floor lintels out of one or both wallfaces (resp.) at that level. This would require a deviation from true verticality of only 0.44° to 0.87°, which would in turn reduce its wallhead diameter by 100 to 200 mm. The circular wall would need a circumferential compression displacement of only 30 to 70 mm to allow the inward tilt. Movement of this scale is inhibited by the circularity of the wall, the close packing of the pinnings and the high density stone packing within the horizontally laid wall core. Movement on this scale could be accommodated by displacement of the sides of the stacked voids and arguably has been at Mousa (see Figures 71-4). It would be ironic indeed if the stacked void, designed to protect the structure from static load, actually facilitates its destruction under the dynamic load of slow and long term creep.

It is suggested that masonry creep can thus amplify settlement displacements and exploit the vulnerability of stacked voids to lateral displacements in drystone built brochs.

It is possible, therefore, that the initiation of creep-amplified deformation can be caused by localised subsidence with ensuing small scale trauma to the masonry that facilitates spread in the adjacent walls under circumferential forces. The writer's conservation work on the entrance façade at Clachtoll identified and remedied a clockwise drift in the stonework of the façade, away from the triangular lintel which was pinned in place by the entrance passage sidewalls (Barber Forthcoming b. and Appendix Clachtoll).

The care that their builders exercised in building to high stacking densities and void packing, with pinnings or slabs, suggests a cognitive awareness<sup>181</sup> of the threat that circumferential movement could initiate, even if the builders were unaware of the precise mechanism of masonry creep.

An examination of ground loading (GL) would indicate in a general way the vulnerability of broch masonry to subsidence in the first instance. Given the known

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<sup>181</sup> In the sense of being based on perception, memory, judgment, and reasoning.

substrates of brochs, two ground loading (GL) thresholds are indicated, the first at 150 kPa, because GLs in the domain 150<GL<300 kPa would challenge most of the cohesive soils (see Table 8.1 for soil types). The second threshold is 300 kPa because greater GLs challenge most of the non-cohesive soils. The GLs imposed by RSM

**Table 8.1 the ground bearing capacities, under static load, of various subsoil types, measured in kPa or kN/m<sup>2</sup> (from Cooke 2007, 205; based on Bldg Regs 2004)<sup>182</sup>.**

Subsoil	Type	Bearing Capacity (kN/m <sup>2</sup> ) kPa
<b>Rock</b>	Igneous and metamorphic	10,000
	Strong sandstone and limestone	4,000
	Schists and slates	3,000
	Strong shales, mudstones and siltstones	2,000
<b>Non-cohesive soils</b>	Dense gravel or dense sand and gravel	>600
	Medium dense gravel & sand and gravel	<200 to 600
	Loose gravel and loose sand and gravel	<200
	Compact sand	>300
	Medium dense sand	100 to 200
	Loose gravel	<100
<b>Cohesive soils</b>	Very stiff boulder clay, hard clay	300 to 600
	Stiff clay	150 to 300
	Firm clay	75 to 150
	Soft clay and silt	<75
	Peat and made ground	TBA

brochs vary with rock type and between the Inner and Outer Walls. Four tables are set out below, Tables 8.2 and 8.3 record the ground loading for outer walls, sedimentary and hard-rock respectively, and Tables 8.4 and 8.5 similarly record the ground loading of the inner walls<sup>183</sup>.

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<sup>182</sup> The nature of foundations necessary for modern buildings are set out in the Building Regulations, Approved Document A, 2004, which in turn refers to relevant British Standards (BS 6399-1:1996 Dead load) (BS6399-2:1997, Wind loads), etc. However, handbooks of building technology have abstracted from these and other sources, estimates of the bearing capacity of various subsoil types (see Cooke 2007, 205, from which Table 8.1 is derived, or Avallone 1987, 12.21, for comparable, but slightly different, US values).

<sup>183</sup> The details of their calculation are presented in Appendix 4.1 worksheets ‘Mass and Ground Load Sedimentary’ and ‘Mass and Ground Load Hard-rock’ in Tables 7&8 therein.



**Outer and Inner Wall ground loading**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		77	101	123	144	165	186	207	227	247
11		68	90	111	130	150	168	187	206	224
12		61	82	101	119	136	154	171	188	205
13		55	74	92	109	125	141	157	172	188
14		50	68	84	100	115	130	145	159	174
15		46	63	78	93	107	121	134	148	162
16		42	58	72	86	99	112	125	138	151
17		38	54	67	80	93	105	117	129	141
18		35	50	63	75	87	99	110	121	133
19		32	46	59	71	82	93	104	114	125
20		30	43	55	66	77	87	98	108	118
21		28	40	52	63	73	83	92	102	112
22		26	38	49	59	69	78	88	97	106
23		24	36	46	56	65	74	83	92	101
24		22	33	44	53	62	71	79	87	96
25		20	31	41	50	59	67	75	83	91

**Table 8.2 Outer Wall, ground loading in kPa, for sedimentary rock types with SBD of 1.6. Cells to the right of the double red line border indicate brochs above the 150 kPa threshold.**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		96	126	154	181	207	233	258	284	309
11		86	113	138	163	187	211	234	257	280
12		77	102	126	148	170	192	213	235	256
13		69	93	115	136	156	176	196	216	235
14		63	85	106	125	144	163	181	199	217
15		57	78	97	116	134	151	168	185	202
16		52	72	90	108	124	141	157	173	188
17		48	67	84	100	116	131	147	162	176
18		44	62	79	94	109	123	138	152	166
19		41	58	73	88	102	116	129	143	156
20		37	54	69	83	96	109	122	135	147
21		35	51	65	78	91	103	116	128	140
22		32	47	61	74	86	98	109	121	132
23		30	44	58	70	81	93	104	115	126
24		27	42	54	66	77	88	99	109	120
25		25	39	51	63	74	84	94	104	114

**Table 8.3 Outer Wall, ground loading in kPa, for hard-rock types with SBD of 2.0. Cells to the right of the double red line border indicate brochs above the 150 kPa threshold. The cell shaded red lies above the 300k Pa threshold.**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		145	189	234	278	323	367	412	456	501
11		131	172	212	252	293	333	373	414	454
12		120	157	194	231	268	305	342	378	415
13		111	145	179	213	247	280	314	348	382
14		103	134	165	197	228	260	291	323	354
15		95	125	154	183	212	242	271	300	329
16		89	116	144	171	198	226	253	281	308
17		84	109	135	161	186	212	237	263	289
18		79	103	127	151	175	199	223	248	272
19		74	97	120	143	165	188	211	234	256
20		70	92	113	135	156	178	199	221	243
21		67	87	107	128	148	169	189	210	230
22		63	83	102	121	141	160	180	199	218
23		60	79	97	116	134	153	171	190	208
24		57	75	93	110	128	145	163	181	198
25		55	72	88	105	122	139	156	173	189

**Table 8.4 Inner Wall, ground loading in kPa, for sedimentary rock types with SBD of 1.6. Cells to the right of the double red line border indicate brochs above the 150 kPa threshold, while the red shaded cells indicate brochs that breach the 300 kPa threshold.**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		181	237	292	348	404	459	515	570	626
11		164	215	265	316	366	416	467	517	568
12		150	196	243	289	335	381	427	473	519
13		138	181	223	266	308	351	393	436	478
14		128	167	207	246	285	325	364	403	443
15		119	156	192	229	266	302	339	375	412
16		111	146	180	214	248	282	316	351	385
17		104	137	169	201	233	265	297	329	361
18		98	128	159	189	219	249	279	309	340
19		93	121	150	178	207	235	264	292	320
20		88	115	142	169	195	222	249	276	303
21		83	109	134	160	185	211	236	262	287
22		79	103	128	152	176	200	225	249	273
23		75	98	121	145	168	191	214	237	260
24		72	94	116	138	160	182	204	226	248
25		69	90	111	132	153	174	195	216	237

**Table 8.5 Inner Wall, ground loading in kPa, for hard-rock types with SBD of 2.0. Cells to the right of the double red line border indicate brochs above the 150 kPa threshold, while the red shaded cells indicate brochs that breach the 300 kPa threshold.**

	Outer Wall	Inner Wall
<b>Sedimentary</b>	20-247 kPa	55-501 kPa
<b>Hard-Rock</b>	25-309 kPa	69-626 kPa

**Table 8.6 Summary of the ground loading ranges in kPa for inner and outer walls built in sedimentary or hard-rock types.**

Ground loadings in the region of 150 to 200 kPa could begin to create stability problems for most of the cohesive and some of the non-cohesive substrates<sup>184</sup>. For the outer walls, the higher loadings lie outwith the grey shading suggesting that the outer walls even of the largest surviving brochs were unlikely to have experienced subsidence. The inner wall ground loadings range from 55 to 501 kPa (sedimentary) and 69 to 626 (hard-rock) and so exceed the 150 kPa threshold even within the buildable domain.

Cells indicative of brochs that deliver more than 300 kPa of ground loading are shaded red in the tables above. It is important to note that even this threshold does not indicate inevitable or necessary collapse, it simply indicates that the potential of settlement leading to structural difficulties is significantly higher for them than structures generating lower loadings. Monuments with such heavy loadings lie outwith the zone indicative of the largest surviving brochs, albeit only just so in the case of the hard-rock facies. It cannot be and is not claimed that this apparent correlation between the safety-limiting thresholds for ground loading and the limit of the tallest surviving brochs is proof that even larger brochs were never built because of the limitations of ground loading. However, prior to this study, a constraint on buildability based on of security of footing for the inner wall had not been suspected and the fact that the thresholds of vulnerability would lie so close to the upper bound of the built stock had not been imagined. Substantial further laboratory and fieldwork will be required to test this unanticipated conclusion.

The theoretical static loads of the inner walls lie at or exceed the 150 kPa threshold over the bulk of the buildable range within the domain<sup>185</sup>. This ought to suggest a high failure rate in built brochs and, of course, with only 5 of the extant c. 600

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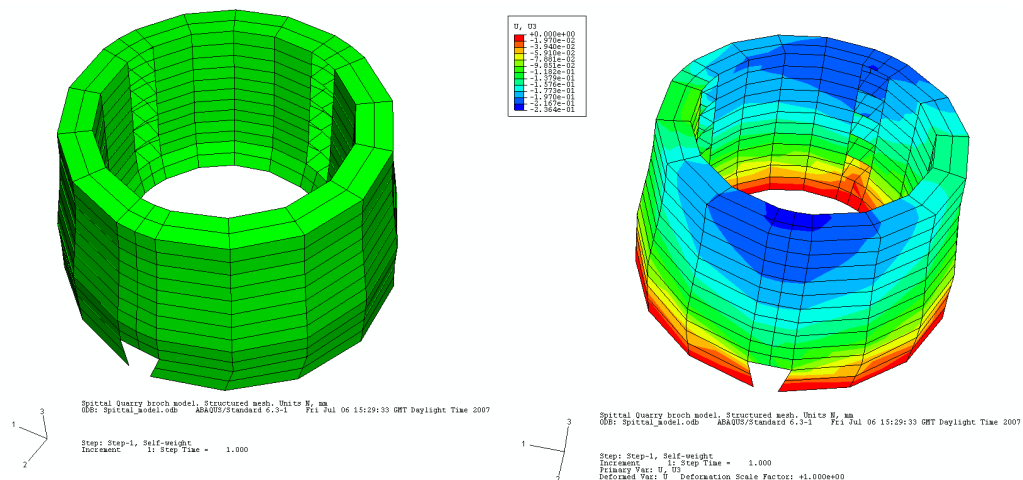
<sup>184</sup> Values less than 100 kPa could still prove challenging for loose gravel, soft clay, silt and also for peat and unconsolidated anthropic deposits, over all of which brochs are known to have been built, at least in part (above).

<sup>185</sup> The domain in this study is that of the interrelationships between the internal radius and the outer wallface slope's deviation from the vertical. The buildable range is the set of cells, each one indicative of a particular domain-relationship, that lies between brochs that are unbuildable small (the pale gold coloured cells) and the tallest examples for which we have surviving evidence (the grey cells).

monuments surviving above the third level this might simplistically be taken as a given. However, the analysis above ignores the major and minor weight-relief systems of the stacked voids. To include them in the calculations would have required individual analyses for each broch, taking account of the scale and position of all voids penetrating the inner wall<sup>186</sup>.

The presence of the 150 kPa threshold within the buildable zone in the tabulation implies that the inner wall structure is generally close to structural vulnerability from settlement, subsidence and creep, both in the substrate and the masonry, and especially vulnerable in the case of hard-rock brochs.

The broch entrance is the weakest part of the structure, not least because it is the only through piercing of the inner and outer broch walls. A finite element analysis of the generic broch form was undertaken by Dr D Theodossopoulos, and part of the result is presented here in Figure 177. These confirm that the entrance area is the seat of the greatest strain in the structure. The long stacked voids can accommodate creep in the inner wall and thus may contribute to longer term instabilities.



**Figure 177 Finite element analysis output for a broch structure undertaken by D Theodossopoulos. The colour coding indicates differential conditions associated with tall stacked voids at entrance and 12 o clock positions. © D Theodossopoulos.**

<sup>186</sup> This was undertaken only for two examples, to test a methodology. These are not reported here other than to observe that it seems likely that the subdivision of the inner wall makes for a less stable situation because a continuous circular wall probably offers horizontal arching in support of the fabric.

The stair access piercing the inner wall and surmounted by a stacked void, also weakens the structural integrity of the inner wall in that area. Although the surviving and observed data did not confirm it unambiguously, it is likely that the access doorway from the stair landing onto the primary scarcement-supported structure in the garth, also sported a tall stacked void. Locally, therefore, the Inner Wall is most likely to be brought to crisis at these piercings. The tall stacked voids are uniformly located in these areas and are not generally encountered elsewhere in the structure.

The fragmentary stacked voids at high levels have been shown for some cases to be relict survivors of episodes of structural failure and rebuilding beneath. It should be noted that the 1 to 3 additional inner wall piercings accessing wall cells and galleries at ground level and the possible short ranges of stacked voids above them are currently discounted as significant factors in ground loading because of their small volumes. Their function seems to have been restricted to that of protecting the cell-entrance lintels and perhaps, secondarily, of admitting light.

It is probable that short stacked voids could have protected the entrance passage lintels also and the selection of the tall voids contains at least an element of architectural choice, *architecture* *sensu* Ruskin as not essential to the structural integrity of the monument.

The reuse of stair foot cells as entrances following the failure of the main entrance arguably indicates the cognitively derived knowledge (*sensu* footnote 9) that in that area the inner wall was already protected by the existence of a stacked void and a further piercing of the outer wall could be assayed here at less risk to the structure than elsewhere.

The unique positional relationship between stacked voids as structural responses and the loci of greatest structural challenge goes directly to the issue of the mind of the builder. It suggests, strongly, a conscious appreciation of the forces involved and the challenges to be met by the structure. That this was probably qualitative and experiential rather than quantitative and numerical is neither here nor there.

It is not impossible that the stresses on the Inner Wall were mitigated somewhat by the gallery floor lintels between the inner and outer walls acting as tie-bars. Their embedment is shallow, averaging 100mm where observable, and it is unlikely that this contribution was other than marginal in sharing the static loads with the outer wall. The outward movement of walls at stairways, as for example at Clickhimin and Dun Carloway, detached the wall from the steps whose function as potential tie-bars, amplified by their number, did not prevent the distortion. It may, however, have contributed to the prevention of total failure and it may be wondered if the presence of two staircases on the ground and first floors, as relatively rigid substructures contributed to the survival of two floors, ground and first, in so many brochs. Similarly, further research might illuminate their impacts on patterns of collapse consequent on the strong rigid sub-assembly they provide. A more sophisticated numerical modelling of the RSM should be undertaken to explore this matter further.

As noted, the RSM exemplar used in these analyses is based on ground galleried broch forms and this may seem to imply an inner wall vulnerability for this form alone. Where the built ground level is actually solid its masonry acts as a foundation-substructure that redistributes the static loads of Inner and Outer Walls across its full footprint reducing the areal ground loads so that even at their maxima, they are within the capacity of most substrates to tolerate<sup>187</sup>. However, at the level of the ground floor wallhead the situation returns to two independent walls with their associated structural implications. Therefore, the generality of the observations made here is not in doubt.

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<sup>187</sup> The carrying capacity of the substrate has been treated in this discussion as a simple parameter with clear failure mode and distinct thresholds to failure. In reality failure under compression in soils is a very complex problem and Terzaghi's theoretical model only offers approximations to reality (Terzaghi, K (1943). *Theoretical soil mechanics*. New York, John Wiley and Sons, Inc.) and these are further modified and simplified by later writers (e.g. Coduto, D P (2001). *Foundation design: principles and practices*. Upper Saddle River, Prentice Hall.). For our purposes, the treatment used here, which is that used in modern building practice, must suffice until an opportunity presents to explore individual monuments in the necessary detail.

## Summary

In general, this assessment of the structural stability of the RSM Ur-broch suggests that the outer wall, whilst more massive, sits on such a large footprint that it is unlikely to challenge the bearing capacity of the solum. Conversely, as the scale of the monument increases, the inner wall rapidly approaches pressures that challenge the majority of soil types. Localisation of fabric damage slows decomposition but even local damage may initiate longer term masonry creep. Even asymmetries of less than a degree in the verticality of the inner wall can threaten its stability, and with it, that of the broch. The completion of the masonry circles especially of the inner wall inhibit destructive movements but the potential exists for unresolved circumferential forces to find expression in movement in the sidewalls of the stacked voids.

## The cost and duration of building brochs

Having considered the mechanics of building brochs, estimates of the costs and duration of building would help relate the physical entity to the social process that allowed their building.

Writing about Orcadian Neolithic chambered cairns Renfrew suggested that a man<sup>188</sup> could quarry a cubic yard of hard stone, i.e. 2600 kg in a day (Renfrew 1979).

Conversely, Mohen also writing about Neolithic monuments, has suggested that a man could transport up to 100 kg of rubble in a day (Mohen 1980).

It is not possible to remove all uncertainties in calculations of work but an attempt is made here to provide a system of calculation that is more transparent and in which the assumptions can be set out to the greatest extent possible. Arguably, this was done by Abrams, the father of architectural energetics in archaeology (Abrams 1994) who set out in extensive and meticulous detail the processes of building Mayan structures and the cost in person days (p-d) units of the construction programme.

The Abrams approach is based on a thorough understanding of the building materials and processes involved and of the various structural forms, from hut to temple, in construction of which they were deployed (Abrams 1994, Chapter 3). The more modest form, which he terms the 'basic architectural form' (ibid, 22-24) was built on low platforms of earth and stone, revetted by a wall. On the platform a low stone wall was built on top of which wattle screens with daub formed the house panels, framed by 4 to 8 main posts. The pitched roof was thatched with palm or grass and the wallfaces were lime-washed. This essentially vernacular architecture (*sensu* Rapoport 1969) was the most persistent form, subject to only minor variations, in all periods and settlement contexts, urban and rural, from 1100 BC to date. Having many excavated examples of all types of Mayan structure available to him, Abrams undertook a Quantity Surveyors (QS) 'bill-of-quantities' approach and used modern vernacular building and experimental archaeology to arrive at p-d costs for

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<sup>188</sup> Renfrew's gender stipulation.



production, transport, construction and reconstruction. Thus, for example quarried stone was costed on the basis of the labour cost of its quarrying, shaping and transport, not on its commodity value.

Abrams' data set is enormous in comparison with that of the Scottish Iron Age structures and specifically in comparison with brochs. We do not have a sequence of building forms in which each is an elaboration of the others or in which the quantification of built content is already known, nor do we have a living building tradition producing the same architectural forms that could serve as comparanda. Starting therefore from a much lower threshold, the writer decided to focus on the physical parameters of energy-use for this architectural energetics study. Essentially, the energy cost of displacing a 1kg mass a given distance under the force of gravity is calculable, and from that, the energy costs of building a broch can be calculable, in units of kilowatt hours (kWh).

The principal assumption herein is that the broch is a standard RSM form structure, whose volume is calculated from its 3-D geometry and its mass from the Specific Gravity of its rock type adjusted for the Standard Bulk density of its built masonry. This has been done in Chapters 4 & 8 (and Appendices 4.1 and 8.2) and the detailed assumptions underlying those analyses are set out there. What follows is a calculation from these masses, of the energy required to quarry, transport and erect the structure. This work provides a direct and consistent comparison between structures, on the basis of the work/energy required to build them.

Human traction was the principal supplier of the work involved. Energy output per person, regardless of gender, has recently been the subject of a major study (Frankenfield, Roth-Yousey et al. 2005) which concludes that humans have a continuous rating of about 75 watts. Thus, an experienced labourer can output 75 watts for about 8 hours per diem, day after day<sup>189</sup>. Avallone *et al* come to the same

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<sup>189</sup> See also Avallone, E A, Baumeister, T (2007). *Marks' Standard Handbook for Mechanical Engineers 11th Edition* New York, Mc-Graw Hill., 9-4; which comes to the same conclusion from modern engineering studies in which mass human labour was deployed.

conclusion from modern engineering studies in which mass human labour was deployed (Avallone 2007, 9-4). Much larger outputs are possible, 400 watts for a sprint-racing cyclist for example, but these are not sustainable over time (see Krendel 1987, 9-168 for comparable examples). Note also Krendel's suggestion that:

Over an 8-hour day for a 48 h-week, a useful norm for a 35-year old labourer for total power expenditure, including basal metabolism energy, is 0.49 hp (366 W). Of this total expenditure, approximately 0.1 hp (75 w) is available for useful work. A 20-year old man can generate about 15 percent more power than this norm and a 60-year old man about 20 percent less. (Krendel 1987, 9-168)

Applying the norm of labour-available 75 watts over an 8-hour period, humans can deliver c 0.6 kWh per diem. This allows us to consider the relationship between energy costs and p-d durations. The remainder of the available energy for each human is a measure of the cost of maintaining life, the Basic Metabolic Rate (BMR) which alone requires 1.743 kWh per diem (Frankenfield, Roth-Yousey et al. 2005). Thus, of the total minimum energy consumed by a working human being, 74% of it is consumed in life maintenance and 26% is available for other activities. Modern studies have not identified gender differences in work capacity and it is assumed throughout this thesis that women were actively engaged in the construction project.

### Energy: physical units and calculations

A force is a push or pull upon an object resulting from the object's *interaction* with another object<sup>190</sup>. A force is said to do work (W) if its interaction with a body results in a displacement (s) of the point of application in the direction of the force (F); thus,  $W = F \cdot s$ . Force is measured in Newtons, and a Newton (N) is equal to the force that would give a mass of one kilogram an acceleration of one metre per second per second;  $1 \text{ N} = 1 \text{ kg} \cdot \text{m} / \text{s}^2$ . Work is measured in joules (J) or Newton metres (N\*m) (IBWM 2006, 116-7) and can be converted to kWh units thus:  $1 \text{ J} = 2.78 \times 10^{-7} \text{ kWh}$ .

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<sup>190</sup> Whenever there is an *interaction* between two objects, there is a force upon each of the objects. Forces only exist as a result of an interaction.

## Quarrying rates

No published work-study for manual extraction rates from stone quarries can be located. The writer has observed over a decade the extraction of flagstone from Caithness quarries from which the overburden had been blasted and machine-stripped. Flagstone removal is undertaken manually, using simple iron wedges and sledgehammers (see Figure 44). A worker with access to a vertical rock face can prise off about 5 m<sup>3</sup> of stone, per person, per diem, indicating a cost-per-kg for quarrying of 0.000055 kWh/kg. Some residuum of waste would have been created in extraction alone, ignoring for the moment the mechanised removal of vast amounts of overburden. Arbitrarily, quarrying waste from the action of quarrying is set here at 3% of the quarried stone for this exercise, a figure roughly based on inadequate experience<sup>191</sup>.

The overall ratio of waste to product in a modern quarry is up to 35:1 and the waste comprises silt and mudstone beds as well as some poorly cemented sandstone beds. Less ideal stone was quarried and used in antiquity but the quality of stone in the surviving flagstone built monuments implies some selectivity in the stone used. Siltstone and mud-stone occurs in the built masonry, but certainly not in the ratios in which they occur in the geological sedimentary sequences. Iron Age quality assurance (QA) procedures were not as rigorous as those practiced in modern Caithness quarries, but the poorest stone types were avoided. The quarry cost of the discard is set here, arbitrarily, at 10%, based on observation and guesswork<sup>192</sup>. Combined, the estimates for wastage indicate an efficiency in building-stone retrieval of 87%, which may be optimistic.

Experience of hand-quarrying of metamorphic and volcanic rock types is not available because the material is so intractable that virtually all modern hard-rock

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<sup>191</sup> The volume of waste is low in part because the stone is not worked after its separation from the bedrock and so losses are restricted to small fragments comminuted by hammer blows or detached by accident or rough handling.

<sup>192</sup> We urgently require some direct experimentation in manual quarrying of stone of all types.

quarrying is now undertaken by machine. In the absence of real data, observation and guesswork suggest that the extraction rate would not be better than one fifth of the extraction rate for flagstone quarrying. In Table 8.7 the relative energy costs of quarrying for hard-rock and sedimentary types has been calculated, per kg of quarried stone. Hard-rock requires 4.23 times as much energy to quarry as sedimentary stone.

Western brochs and some Northern and Shetland brochs are constructed from volcanic and metamorphic rock types. The cost of quarrying for these monuments is over four times higher than the cost of extracting coherently bedded sedimentary rock types. Some part of the explanation of the size difference between the smaller western brochs and the larger eastern brochs may be attributable to this factor.

**Table 8.7 Comparative energy costs, per kg, of quarrying hard-rock (Specific Gravity [SG] 2.6) and sedimentary rock types (SG 2.2).**

Hard-rock		↔	Sedimentary rock	
1 m cu	2.6	tonnes/m <sup>3</sup>	2.2	1 m cu
1 m cu	2600	kg/ m <sup>3</sup>	2200	1 m cu
	2600	kg	11000	5 m cu
0.60 kWh/diem	0.000231	kWh/kg	0.000055	kWh/kg
Allow for efficiency of 87%				
	0.000201	kWh/kg	0.000048	
<b>Energy cost ratio</b>	<b>4.2</b>	<b>:</b>	<b>1</b>	

### Transport of stone

A distinction must be made between the volume of stone required in building and its mass, in kg. These are interrelated by the Specific Gravity (SG, see Table 8.8) and Standard Bulk Density (SBD) of the stone type. Direct measurement of stone fragments from individual monuments suggest that Caithness flagstone has an SG of about 2.2, while the comparable value for a range of volcanic and metamorphic stone types was 2.6.

Volcanic & metamorphic		Sedimentary	
Material	SG	Material	SG
Andesite	2.5 - 2.8	Sandstone	2.2 - 2.8
Basalt/Traprock	2.8 - 3.0	Shale	2.4 - 2.8
Diabase	2.6 - 3.0	Gypsum	2.3 - 2.8
Diorite	2.8 - 3.0	Limestone	2.3 - 2.7
Gneiss	2.6 - 2.9		
Granite	2.6 - 2.7		

Table 8.8 The specific gravities (SG) of common rock types

An SG of 2.2 means that a cubic metre of solid bedrock will weigh 2.2 tonnes. Standard bulk density is a measure of the density of a particulate material, including the air spaces between particles (Marshall, Holmes *et al.* 1996 P 9-10.). Thus, a cubic metre of masonry contains airspaces and its SBD is lower than its SG. In the case of Caithness flagstones an average SBD of 1.6 was determined by direct measurement; representing 1.6 tonnes per cubic metre of built masonry<sup>193</sup>.

An average able-bodied adult human being can safely lift and carry a 25 kg load unassisted (see HSE 1992 *Appendix 3* for discussion). Some individuals can lift heavier and some only lighter loads and carry them for longer or shorter periods, but this is a good working average<sup>194</sup>. To provide an index of work done, the energy cost of horizontally displacing 25 kg over 9 km is 0.61 kWh, or roughly the consistent daily work capacity of an adult human. At the level of approximation being used here, it does not matter whether this work is undertaken as a single operation or the sum of many separate loads over shorter distances. The horizontal movement of 25

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<sup>193</sup> Stone masons use a rule of thumb which sets the SBD at two thirds the SG, which would yield a SBD of 1.5 in this instance.

<sup>194</sup> Backpackers typically carry loads of this magnitude for a whole day of walking. The Health and Safety guidance on materials handling, referred to above, suggests that 25kg is an acceptable load, albeit for men with a lower threshold for women. The writer supposes that the gender differentiation in this instance is a social construct, not a real physical limitation. The British Army's Annual Fitness Test for infantry soldiers requires them to march 12.9 km carrying a 25kg load.

kg over, say, 100 m could be undertaken some 88 times<sup>195</sup> for roughly the same energy cost<sup>196</sup>.

**Table 8.9 The energy cost of displacing 25 kg of stone over 100 m in the horizontal plane. This assumes a tare weight allowance of 6.25kg for basketry, backpack or other stone carrying device.**

Distance (m)	Load (kg)	Speed (kph)	Min Duration (s)	kWh
100	0	2	180	0.00212813
100	31.25	2	180	0.0085125
200	31.25		360	0.01064063
<b>Trips per daily work-energy availability .6 kWh</b>				56

On the basis of observations made during the construction of half and full scale broch segments in Caithness, this estimate of 56 trips per diem does not seem wholly improbable, but food and rest breaks and cumulative inefficiencies would reduce the number of trips by 10% to 20% (Table 8.10). Thus, a total of between 45 and 51 trips seems more credible. For the current calculations, the lowest estimate, 45 trips is adopted as the guideline figure, indicative of moving 1125 kg of material per diem (see Table 8.10). This would allow an additional 10.6 minutes per roundtrip to allow for queueing, loading and unloading at each end and this also squares with field observation. The value of 1125 kg transported by hand per-diem is assumed in these calculations and used extensively in the energy cost calculations that follow.

The reader will be aware of the uncertainties in these calculations and no precision is claimed for them. Rather, they provide a consistent basis for exploring the comparative energetics of broch building such that the costs can be compared

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<sup>195</sup> This is derived by dividing 9km by 200m; allowing 100m each way per trip, laden on the delivery leg and unloaded on the return.

<sup>196</sup> However, this assumes 100% efficiency in the operations and implies, for example, that the individual would walk on level ground for 100 m, pick up a 25 kg load, deliver it and return to the source and then, without hesitation embark on the next trip, and so on. Based on field work observations in Caithness, the writer suggests that this is not credible. In addition, the use of a harness, like a shoulder basket or a head band or knapsack type arrangement can add up to 6.25 kg to the burden to be carried.

between structures, even if the absolute values are indefensible. The results of these calculations are used comparatively, not as absolute measures, and any adjustment to the values used should increase or reduce all the outcomes proportionately. In setting out the imponderables, it is hoped that they will be tested by field research and indeed some is already planned for the 2017-2020 period.

**Table 8.10 The relationship between time, number of trips and weight of stone moved**

<b>trips</b>	<b>56</b>	<b>45</b>	<b>51</b>
<b>minutes</b>	336	270	306
<b>hours</b>	5.6	4.5	5.1
<b>Total kgs</b>	1400	<b>1125</b>	1275

Use of carts would have greatly reduced the need for manual carriage. A wooden axle can support c. 800 kg and a horse-, or ox-drawn cart with two axles appropriately loaded could transport up to 1.6 tonnes. Allowing for the tare weight of the 2-wheeled cart itself and for some degree of caution in the lading, a maximum load<sup>197</sup> of say 450 kg (56% of theoretical maximum load) or 18 person loads might be a reasonable guesstimate, with doubling of these figures for the 4 wheeled cart. This would be equivalent to 4/10 person-day (p-d) and 8/10 p-d in a single load on a two wheeled and four wheeled cart, respectively. Thus if we allow, say 10 cart trips in a day the cartage would equate with 4 p-d and 8 p-d respectively of work done.

The carter would probably have been involved in loading and unloading but it is likely that additional personnel were used at each end of the trip. Overall a clear additional 3 p-d of work was achieved for each two wheeled cart and 7 p-d for each four wheeled cart for every 10 trips.

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<sup>197</sup> Compared with the Red River ox cart, which could carry 1000 lbs on wooden axles with unlubricated wheel hubs (their consequent squealing earned them the sobriquet 'the northwest fiddle') see; [https://en.wikipedia.org/wiki/Red\\_River\\_cart](https://en.wikipedia.org/wiki/Red_River_cart); a more extensive account of the more technically accomplished Roman cartage is provided in Weller, J A "Roman Traction Systems." Der Humanist.

That wheeled vehicles were available in the Scottish Iron Age is not in doubt. Earlier, Bronze Age spoked and solid wheels have recently been excavated from Must Farm, Peterburgh, England<sup>198</sup>. Several Roman Period wheels have been recovered in Scotland, as for example in Carlisle (McCarthy 2002 his Figure 54) but Iron Age cart wheels are rather unknown in Scotland. This is however an accident of preservation rather than an absence of cartage.

Nevertheless, it is not known how many and what type of carts were in fact used in broch building. Therefore, no further consideration is given to this matter here, but it is very likely that cartage was used and that it would have significantly reduced the duration of the haulage phase of the building project.

### **Rough ground and gradients**

Carrying 25kg of stone over rough and broken ground would multiply the energy requirement by a significant factor, potentially doubling the total energy cost. However, this could only be accurately estimated in the particular individual circumstances of a given site. The health and safety risk of moving a large weight over broken ground is also quite significant and may have encouraged the use of wheeled transport. It is suggested that in future projects, a specific field exploration for prepared pathways and cart tracks should be undertaken<sup>199</sup>.

The energy cost of moving material up or down gradients is calculable, but for simple calculation requires the assumption of smooth progress up a linear slope. The

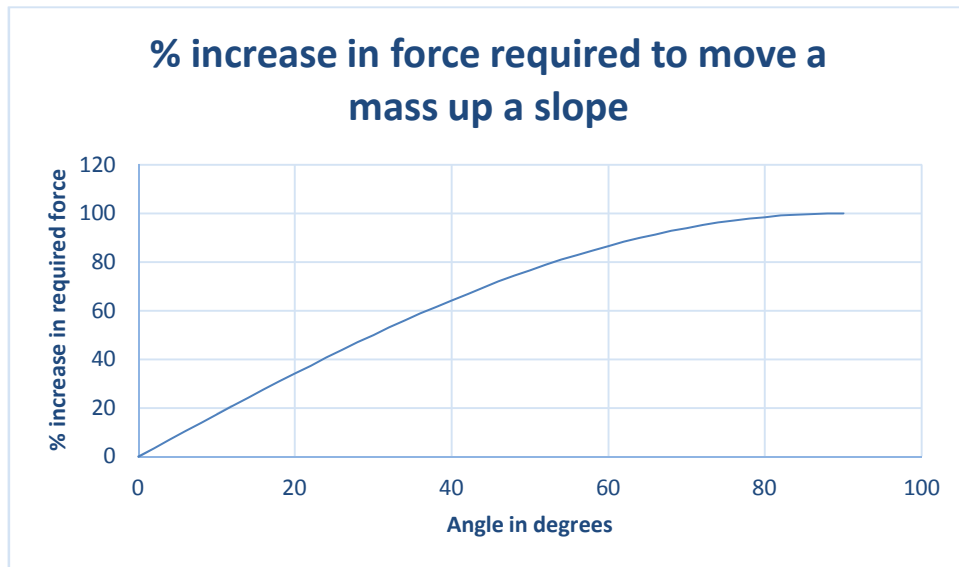
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<sup>198</sup> See <http://www.cam.ac.uk/research/news/most-complete-bronze-age-wheel-to-date-found-at-must-farm-near-peterborough>.

<sup>199</sup> Cart tracks have been observed under the burial mound of the Neolithic monument at Flintbek, North Germany, dating to 3420-3385 BC. Mischka, D (2011). "The Neolithic burial sequence at Flintbek LA 3, north Germany, and its cart tracks: a precise chronology." *Antiquity* 85(Sept): 742-758. Whole landscapes covered with cart tracks are found in Malta and are variously attributed dates of unknown validity (Mottershead, D, A Pearson and M Schaefer (2008). "The cart ruts of Malta: an applied geomorphology approach." *Antiquity* 82(318): 1065-1079.).



mass of 25kg under gravity exerts a force of 245N. Placed on an inclined plane (or slope) the work involved in moving the mass increases proportionate to  $\text{Cos } \alpha$ , where  $\alpha$  is the angle between the slope and the horizontal plane.



**Figure 178** The percentage additional force (Y axis) required to displace a mass (i.e. the 25 kg stone) up a slope whose angle is expressed in degrees (X axis). It will be clear that at 30 degrees, the force required will increase by 50% (from 245 to 367.5N) and so on.

The terrain in the immediate vicinity of brochs is rarely level and indeed is often highly variable. A very, very approximate value of c  $5^{\circ}$  to  $6^{\circ}$  may not be untypical of the slopes around brochs. At  $6^{\circ}$ , the increase in the work required to carry weight uphill would be 10%<sup>200</sup> (Figure 178). In dealing with variable slopes on the approach routes, it seems reasonable to take the  $6^{\circ}$  slope as an index of the average percentage increase in energy cost of transporting stone to the building site<sup>201</sup>. This can be applied as a 10% efficiency reduction in the cost of transport.

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<sup>200</sup> Figure 178 Deals with force, but since this is a simple multiplier in the work formula, the increase in work costs (in kWh) is directly proportional to the increase in force.

<sup>201</sup> For future studies, agent based modelling could be programmed to take account of the real world ground conditions surrounding the structure, as well as to seek out probable quarry sites and the most energy-efficient routes from them to the structure (see for comparable examples, Kohler, T and G J

## The building project

Given the energy costs and probable durations of quarrying and transport, it is likely that these activities were undertaken in advance of building, probably seasonally and possibly over a significant period of time and that the materials were stockpiled at the building site. The on-site handling of material would have included grading and sorting of stone in discrete piles before serving the masons the most appropriate material. It is possible that this would amount to the equivalent energy cost of carrying the material say 20 m, averaged over the total building mass. This is the materials handling component of the build cost.

Then the stone was lifted to the working level and incorporated into the structure. Accepting that vertical displacement doubles the work requirement (Figure 178), the human work rate can be halved to yield an estimate of the cost of lifting the stone into place, in kWh.

Given built masses as set out in Appendix 4.1, the calculations referred to hereunder are set out in Appendix 8.1 in worksheets 'Sedimentary Construction' and 'Hard Rock Construction'. There, for brochs in the radius and batter-angle ranges already defined, estimates of the gross cost of quarrying, nominal transport (over a distance of 100 m horizontally), on site handling, tower building and the global costs of the build are set out in kWh. Also included in the worksheets are tables of the duration, in person days, p-d, and in team days for these various activities.

Below the tables of global cost of build, the global durations in p-d and team-days are presented, for sedimentary rock brochs (Tables 11, 12 and 13) and for hard-rock (Tables 14, 15 and 16). It is possible to locate in these tables any particular broch either by finding the corresponding values of  $r$  and  $\theta$ , or by substituting the precise values in the Appendices 4.1 and 8.1.

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Gumerman (2000). *Dynamics of human and primate societies : agent-based modeling of social and spatial processes*. New York ; Oxford, Oxford University Press.).

**Table 8.11 Sedimentary brochs: Global costs, in kWh, from quarrying to completion. (see table 11 in ‘Sedimentary construction’ worksheet, Appendix 8.1)**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		865	1500	2351	3446	4815	6488	8493	10860	13618
11		776	1351	2122	3114	4356	5872	7690	9836	12337
12		702	1227	1931	2838	3972	5358	7020	8981	11267
13		639	1121	1769	2603	3646	4922	6451	8256	10360
14		584	1031	1629	2401	3367	4547	5962	7633	9581
15		537	952	1508	2226	3123	4221	5537	7091	8903
16		496	883	1402	2072	2910	3935	5164	6616	8308
17		459	821	1308	1935	2721	3682	4834	6195	7782
18		427	767	1224	1814	2553	3456	4540	5820	7312
19		397	718	1149	1705	2401	3253	4275	5483	6890
20		371	673	1080	1606	2265	3070	4036	5178	6509
21		347	633	1019	1517	2140	2903	3819	4901	6163
22		325	596	962	1435	2027	2752	3621	4649	5847
23		304	563	910	1360	1923	2612	3439	4417	5557
24		286	532	863	1291	1827	2484	3272	4204	5290
25		269	503	818	1227	1739	2365	3117	4006	5043

**Table 8.12 Sedimentary brochs: Global sequential duration of the build project in p-d. (see Table 12 in ‘Sedimentary construction’ worksheet, Appendix 8.1)**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		1442	2500	3918	5743	8025	10813	14155	18100	22696
11		1294	2252	3536	5191	7260	9787	12817	16394	20562
12		1170	2045	3218	4729	6620	8930	11699	14969	18779
13		1064	1869	2948	4338	6077	8203	10751	13760	17267
14		974	1718	2715	4002	5611	7578	9937	12722	15968
15		895	1586	2514	3709	5206	7035	9229	11819	14838
16		826	1471	2336	3453	4850	6558	8607	11027	13847
17		765	1369	2180	3226	4535	6136	8057	10325	12969
18		711	1278	2040	3023	4254	5760	7566	9700	12187
19		662	1196	1914	2841	4002	5422	7125	9138	11484
20		618	1122	1801	2677	3774	5117	6727	8630	10849
21		578	1055	1698	2528	3567	4839	6366	8169	10272
22		541	994	1603	2391	3378	4586	6035	7748	9745
23		507	938	1517	2266	3205	4354	5732	7362	9262
24		477	886	1438	2151	3045	4140	5453	7006	8817
25		448	838	1364	2044	2898	3942	5195	6677	8405

**Table 8.13 Sedimentary brochs: Duration of the build project in days, using teams**  
(see Table 13 in ‘Sedimentary construction’ worksheet, Appendix 8.1)

Team size	20	30	40	50	60	70	80	90	100
$\alpha$ r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10	72	83	98	115	134	154	177	201	227
11	65	75	88	104	121	140	160	182	206
12	58	68	80	95	110	128	146	166	188
13	53	62	74	87	101	117	134	153	173
14	49	57	68	80	94	108	124	141	160
15	45	53	63	74	87	100	115	131	148
16	41	49	58	69	81	94	108	123	138
17	38	46	54	65	76	88	101	115	130
18	36	43	51	60	71	82	95	108	122
19	33	40	48	57	67	77	89	102	115
20	31	37	45	54	63	73	84	96	108
21	29	35	42	51	59	69	80	91	103
22	27	33	40	48	56	66	75	86	97
23	25	31	38	45	53	62	72	82	93
24	24	30	36	43	51	59	68	78	88
25	22	28	34	41	48	56	65	74	84

**Table 8.14 Hard-Rock brochs: Global costs, in kWh, from quarrying to completion.**  
(see Table 11 in ‘Hard-rock construction’ worksheet, Appendix 8.1)

$\alpha$ r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10	1205	2090	3275	4801	6708	9038	11832	15129	18971
11	1081	1882	2956	4339	6068	8181	10713	13703	17187
12	978	1709	2690	3953	5533	7464	9779	12512	15697
13	890	1562	2464	3626	5080	6856	8987	11502	14433
14	814	1436	2270	3345	4690	6334	8306	10634	13347
15	748	1326	2101	3101	4351	5880	7714	9879	12403
16	691	1230	1953	2886	4054	5482	7194	9217	11574
17	640	1144	1822	2696	3791	5129	6734	8630	10841
18	594	1068	1705	2527	3556	4814	6324	8107	10186
19	553	1000	1600	2375	3345	4532	5956	7638	9599
20	516	938	1505	2237	3155	4277	5623	7214	9068
21	483	882	1419	2113	2982	4045	5321	6828	8586
22	452	831	1340	1999	2824	3833	5045	6476	8145
23	424	784	1268	1894	2679	3639	4791	6153	7741
24	398	741	1202	1798	2545	3460	4558	5856	7370
25	374	701	1140	1709	2422	3295	4343	5581	7026

**Table 8.15 Hard-Rock brochs: Global sequential duration of the build project in p-d.**  
(see Table 12 in ‘Hard-rock construction’ worksheet, Appendix 8.1)

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		2009	3483	5458	8001	11180	15064	19719	25215	31618
11		1802	3137	4926	7231	10113	13634	17855	22838	28644
12		1629	2848	4483	6589	9222	12440	16298	20853	26161
13		1483	2603	4106	6043	8466	11427	14978	19170	24055
14		1357	2393	3783	5575	7817	10557	13843	17723	22244
15		1247	2210	3502	5168	7252	9800	12856	16465	20671
16		1151	2049	3255	4810	6757	9136	11991	15361	19290
17		1066	1907	3036	4494	6318	8548	11224	14384	18068
18		990	1780	2842	4212	5927	8024	10540	13512	16977
19		922	1666	2667	3958	5575	7553	9927	12730	15998
20		861	1563	2509	3729	5258	7128	9372	12023	15113
21		805	1470	2365	3521	4970	6741	8868	11380	14309
22		754	1385	2234	3331	4706	6389	8408	10794	13575
23		707	1306	2114	3157	4465	6065	7986	10256	12902
24		664	1234	2003	2996	4242	5767	7597	9760	12283
25		624	1168	1900	2848	4037	5491	7238	9302	11709

**Table 8.16 Hard-Rock brochs: Duration of the build project in days, using teams.**  
(see Table 13 in ‘Hard-rock construction’ worksheet, Appendix 8.1)

Team size	20	30	40	50	60	70	80	90	100	
$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		100	116	136	160	186	215	246	280	316
11		90	105	123	145	169	195	223	254	286
12		81	95	112	132	154	178	204	232	262
13		74	87	103	121	141	163	187	213	241
14		68	80	95	111	130	151	173	197	222
15		62	74	88	103	121	140	161	183	207
16		58	68	81	96	113	131	150	171	193
17		53	64	76	90	105	122	140	160	181
18		50	59	71	84	99	115	132	150	170
19		46	56	67	79	93	108	124	141	160
20		43	52	63	75	88	102	117	134	151
21		40	49	59	70	83	96	111	126	143
22		38	46	56	67	78	91	105	120	136
23		35	44	53	63	74	87	100	114	129
24		33	41	50	60	71	82	95	108	123
25		31	39	48	57	67	78	90	103	117

It is important, clearly, to use the appropriate sedimentary or hard-rock table and to be aware of the differences between cost and duration.

**Table 8.17** The cost differences between hard-rock and sedimentary rock types expressed as person-day costs. M signifies Midhowe, DC Dun Carloway and G Gurness.

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		567	983	1540	2258	3155	4251	5564	7115	8922
11		509	885	1390	2041	2854	3847	5038	6444	8083
12		460	804	1265	1859	2602	3510	4599	5884	7382
13		418	735	1159 M	1705	2389	3225	4226	5409	6788
14		383	675 DC	1067 DC	1573	2206	2979	3906	5001	6277
15		352	624	988	1458	2046	2765	3628	4646	5833
16		325	578	918	1357	1907	2578	3383	4335	5443
17		301	538	857	1268 G	1783	2412	3167	4059	5098
18		279	502	802	1188	1672	2264	2974	3813	4791
19		260	470	752	1117	1573	2131	2801	3592	4514
20		243	441	708	1052	1484	2011	2645	3393	4265
21		227	415	667	994	1402	1902	2502	3211	4038
22		213	391	630	940	1328	1803	2372	3046	3831
23		199	369	596	891	1260	1711	2253	2894	3641
24		187	348	565	846	1197	1627	2144	2754	3466
25		176	329	536	804	1139	1550	2042	2625	3304

In Table 8.17 the cost and duration differentials between hard-rock and sedimentary brochs are set out; hard-rock always more expensive. Onto this table the positions of Midhowe (M), Gurness (G) and Dun Carloway (DC) have been marked. In Table 8.19 the brochs in the range have been expressed as multiples of the smallest example. Midhowe and Gurness are both about 7 times the cost of the smallest sedimentary broch and Dun Carloway, about 5 times the cost of the smallest hard-rock broch. Their costs, in raw working days are set out in table 8.18. This places them very close to each other in terms of their construction costs; Gurness is 6% more expensive and Midhowe 3% less expensive than Dun Carloway. Despite the manifest differences observable between them in the field, they represent a similar social investment, represented by construction costs. This is an unanticipated conclusion that rather reduces the significance of the size differences between east and west coast brochs; they share a similar level of social investment.

Brochs	Base broch Multiples	p-d cost	Ratio to smallest
Gurness	7	3226	1.09
Dun Carloway	5	3038	1.03
Midhowe	7	2948	1.00

**Table 8.18** Cost comparisons

Regrettably only a handful of reliable records of radius and external batter angle exist and the recovery of more and more reliable data is an urgent priority for ongoing research. In the meantime, the inadequate but available data suggests that the bulk of the brochs may occupy a quite restricted part of the range surrounding the three exemplar monuments.

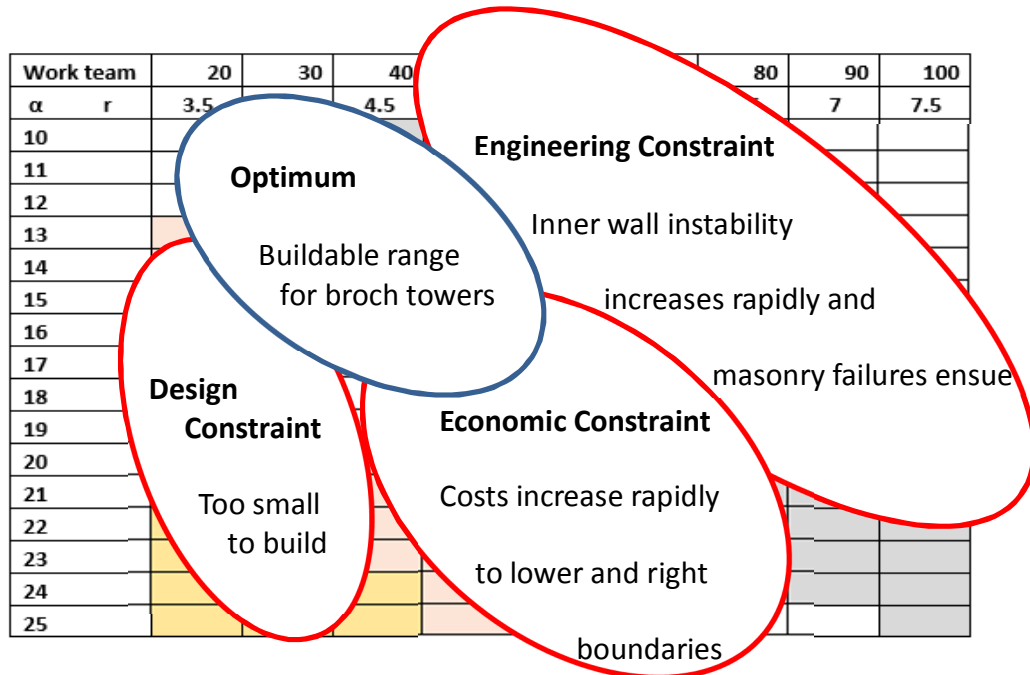


Figure 179 The research range as a decisions constraint domain in the mind of the builder

### The major constraints

The work described thus far has identified three major constraints on the mind of the builder, a design constraint that rules out the smallest structures, a stability constraint that limits the largest and a cost constraint that further constricts the buildable domain (Figure 179). The limitation by cost may mask a further social constraint which is that the sizes of brochs may have been constrained by the availability of labour and the capacity to sustain it. If, for example, work crews larger than 40 or 50 persons were simply not available to the common social unit of the day, then the availability of the resources to pay them would be moot.

**Table 8.18 total build cost (left) and duration of build, (right) both expressed in multiples of the smallest broch.**

$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		3	6	9	13	18	24	32	40	51
11		3	5	8	12	16	22	29	37	46
12		3	5	7	11	15	20	26	33	42
13		2	4	7	10	14	18	24	31	39
14		2	4	6	9	13	17	22	28	36
15		2	4	6	8	12	16	21	26	33
16		2	3	5	8	11	15	19	25	31
17		2	3	5	7	10	14	18	23	29
18		2	3	5	7	9	13	17	22	27
19		1	3	4	6	9	12	16	20	26
20		1	3	4	6	8	11	15	19	24
21		1	2	4	6	8	11	14	18	23
22		1	2	4	5	8	10	13	17	22
23		1	2	3	5	7	10	13	16	21
24		1	2	3	5	7	9	12	16	20
25		1	2	3	5	6	9	12	15	19

Team size	20	30	40	50	60	70	80	90	100	
$\alpha$	r	3.5	4	4.5	5	5.5	6	6.5	7	7.5
10		3	4	4	5	6	7	8	9	10
11		3	3	4	5	5	6	7	8	9
12		3	3	4	4	5	6	7	8	8
13		2	3	3	4	5	5	6	7	8
14		2	3	3	4	4	5	6	6	7
15		2	2	3	3	4	5	5	6	7
16		2	2	3	3	4	4	5	6	6
17		2	2	2	3	3	4	5	5	6
18		2	2	2	3	3	4	4	5	6
19		1	2	2	3	3	3	4	5	5
20		1	2	2	2	3	3	4	4	5
21		1	2	2	2	3	3	4	4	5
22		1	1	2	2	3	3	3	4	4
23		1	1	2	2	2	3	3	4	4
24		1	1	2	2	2	3	3	4	4
25		1	1	2	2	2	3	3	3	4

The calculated costs and durations of the build projects are not inherently improbable, even if they are not in any meaningful sense proven by the analysis. However, these tables assume a flat-pack project in which each task follows the previous with no overlap; an improbable situation. It is more likely that the quarrying was done in advance and the construction could have been completed in less than half the global project duration. The cost estimates are of course only about a quarter of the actual costs because they calculate the work-available energy of the humans involved, at 0.6 kWh/d. But each worker expended 1.743 kWh in staying alive. Thus the tabulated estimates can be increased roughly fourfold, to arrive at the actual cost of the project which can then be converted to calories by the standard constant to arrive at food quantities on the supply side of the contract.

To allow for alterations to the various assumptions, each resultant duration can be adjusted by a constant proportion in Appendix 8.1, when curiosity prevails or better information is to hand. However, the relative durations of build would probably remain constant. In Table 8.18, these proportions are expressed relative to the smallest broch (bottom left in the table). The cost of larger buildings increases for more rapidly than the duration of their construction with the greatest cost in the range set at 51 base units while the longest duration is only 10 times the base units, i.e. the smallest broch.





## Chapter 9 Discussion and conclusion

### Introduction

The research reported above has shown that broch towers are canonical structures of the form set out in the RSM (Figure 36). Their complex structures and elegant engineering solutions result from a coherent and possibly a single act of creation, neither being previously possible or necessary without the other. Their apparent heterogeneity results from the patterns of natural and anthropic change that they underwent. The designed broch tower is such a strong form and structure that it constrained its own decomposition and so patterns emerged within that decomposition which cloud past perceptions of the original monument form. These have been recorded here, some for the first time ó the upward migration of the ground floor following infilling and affecting entrance structures and midlevel scarcements, *inter al* ó some already recognised ó secondary doors through the stairfoot ó but both now intelligible within the revised standard model (RSM) and the paradigm it represents.

### Research questions and some answers

The first of the operational null hypotheses set out in Chapter 5 proposed that brochs are not canonically built to the RSM norm. Exploration of the remains demonstrated that this is untrue and the information leading to this conclusion can be found in Chapters 6 through 8. The presence of the features characterising the RSM (Figure 36) have been confirmed by observation 19 times more frequently than refuted and many of the refutations are consequences of secondary structural modifications. The weight management structures in the entrance have been observed consistently as have stacked voids over the stair ensemble. Where the inner walls are accessible at ground level, they are uniformly circular to better than  $\pm 30\text{mm}$  even where the broch wall footings are on uneven ground or initiated as isolated segments. The outer wall circularity however remains in doubt and being sometimes tailored to landform is inevitable non-circular other than in orthographic section. In some instances, non-circularity indicates a rebuild. The stones of the wall cores, where accessible are clearly horizontally laid with maximum stacking density (minimum air space). These

consistent observations support the hypothesis that these brochs are canonical tower structures and that the RSM is, taken at the very least, a good first approximation to the ðUr-broch canonical form.

The second operational null hypothesis was that broch remains have not been modified by natural or anthropic forces and again this has been strongly negated. The case studies in Chapters 6 & 7 demonstrate the ubiquity of large scale alteration and the later reformation and reuse of the modified broch structures. Inherent limitations in the design response to management of dead load and localised failures from subsidence, both lead to patterns of decomposition, often arising from the longer term slow-acting process identified as ðmasonry creep in this thesis where it has probably been formally identified in prehistoric remains for the first time. Masonry creep has been identified as the likely causes of ðnatural settlement in the structures, leading to potentially major failures. Because the failures are predicated in design weaknesses, patterns are observable in the alterations to brochs, of which the one already known was the failure of the designed entrance and the reuse of stairfoot cells as secondary entrances. Patterns of anthropic alterations are also evidenced of which the commonest arise from responses to the infilling of the broch's garth with collapsed material, settlement detritus and secondary structures. These modifications allow/require the migration upwards of the garth floor level and eventual reestablishment of a new operating level, usually at the top of the original ground floor. This explains mid-level scarcements as secondary modifications, together with the slapping out of the original entrance lintels, migration of the entrance opening upwards and remodelling of now relict stacked voids. Mistaken in the past for original and heterogeneous features, these attributes form a coherent path to decomposition. Far from undermining the canonical RSM hypothesis, they confirm it by demonstrating the constraint of the original design on the available structural responses following failure. Until the broch remains were fully subsumed in the developing villages of the east and north, there was no divergent path to decomposition. The original form of the RSM is observable in all of the cases examined (having excluded the semi brochs and Jarlshof) and the observable

deviations from it are uniformly attributable to decomposition along a trajectory constrained by the canonicity of the original build.

While the full range of broch modifications and alterations can be observed most clearly in the eastern and northern brochs, the scale and frequency of modification of western brochs was not anticipated prior to this study. In the case of Dun Carloway, the artist's model for the SM2012 reconstruction (Figure 26**Error! Reference source not found.**), a long history of significant masonry failure and rebuild can still be discerned<sup>202</sup>.

The fact that Western brochs are smaller and more likely to be ground galleried than Eastern examples has long been noted and attributed to lithological differences by Romankiewicz and MacKie. It has been shown above that despite these physical differences, the social costs of their construction can be close to identical. In addition, hard-rock (mostly Western) and sedimentary (mostly Eastern) brochs are also structurally identical and the RSM is as evident in the west as it is in the east. Brochs were built over the whole of their known distribution to the same canonical design. It also implies a cultural continuity over this range in the fourth/third century BC.

The substantive differences emerge at a later date. The western brochs lack the village settlements of their eastern and northern equivalents and thus appear distinctly different from them, but only in terms of an arrested development with no evidence for the trend to agglomeration of settlement in the west. It is clear that cultural processes changed or intensified on the east coast and in the northern isles and that village formation was one part of that social intensification in the North Sea province. The true Atlantic coast and its islands did not experience that social intensification. MacKie has written about the differences in artefactual assemblages between east and west, the former richer the latter poorer at least in the volumes of

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<sup>202</sup> These are slightly less visible now than they once were, mainly as a result of overactive conservation but Captain Thomas referred to 'so many proofs of reconstruction...on Dun Carloway (Thomas 1890, cited in MacKie 2007b, 1095).

recovered material, and this underlines the east/west geography of social differentiation in the second and first centuries BC and AD. No historical or cultural explanation has been raised hitherto to explain this differentiation, largely because of the LDCU assumption that the differentiation was a characteristic of brochs, indicative of social divides extant from their beginning. The strength of the canonical RSM hypothesis now suggests otherwise. The brochs were built canonically over the entire territory and the social context of the territory differentiated subsequently.

Finally, the third operational null hypothesis was that brochs are independent of the social contexts in which they are created, modified and used or reused over time. This also was contradicted from the outset by the nature of the broch tower itself. Incapable of Darwinian evolution by incremental changes to meet smoothly evolving demands, the tower derived from a step-change Lamarckian evolution which was imposed by humanity in response to social needs. The Lamarckian step-change rather militates against a vernacular social context for its construction. To the consistently deployed engineering solutions to towering challenges, can be added the complexity of the project management processes involved and the costs of construction which again militate against the low level, local enterprise character of vernacular construction processes. The canonicity of the built form, varying only in scale, especially of cost, and the absence of patterns of regional variation, also argue against an interpretation founded in the vernacular construction tradition. Finally, surveying in and levelling the build of the tower, even from wildly uneven footings, while retaining circularity to close tolerances all required skills and expert knowledge which there is no *a priori* reason to assume were commonplace on a working farm. Flannery and Marcus 1993

It is concluded therefore that broch towers were built to a cognitively created design and their construction was managed by professionals who possessed skill levels in the management and supervision of the build that were unattainable in the vernacular arena. In using the term 'cognitively' here the writer takes what Johnson would call a cognitive-processualist approach (Johnson 2010, 99-101) close in character to the approaches adopted by Flannery and Marcus (see for example Flannery and Marcus 1993). It is argued that whilst the cognitive processes of the broch builders cannot be

known directly, their operations formed material consequences from which the general shape of those cognitive processes can perhaps be imperfectly discerned. This approach is close also to that of Renfrew and Zubrow 1994 for whom cognitive archaeology subsists in the recovery of evidence for an original conscious capacity that is recoverable by inference from patterns of archaeological deposits or structures.

The broch tower decomposed along a consistent trajectory, as noted above, and became in its decomposition an anthropic environment with which humans interacted at levels ranging from squatting within the ruins to remodelling them for new social uses. The continuing value of the broch as a resource has been highlighted (Tait 2005) and is sadly observable in the steadily deteriorating condition of many monuments. Broch remains were and some continue to be sufficiently large to become landscapes and environments themselves and to affect the social landscapes in which they are found and through which they have passed.

## Chronologies

Observation and analysis of the broch remains can only supply a relative chronology and so called 'absolute dating' is required to move this into a calendrical framework. Conventionally, i.e. SM2012 brochs the dates of brochs are constrained by MacKie's determination that they were built by southern invaders or migrants arriving in Scotland c. 200 BC. In consequence, earlier dates are dismissed as 'too early'. However, the early dates from Thrumster (Appendix Thrumster) and from Old Scatness (Dockrill, Outram et al. 2006) are consistent with each other and consistent also with the lengthy history of masonry manipulation evidenced at Thrumster and the relatively large numbers of dates assayed at both sites.

It is therefore argued that the brochs were built in the fourth or early third centuries BC and being canonical constructions may have all been built in a relatively short period, probably less than a century and perhaps less than a generation. Over time, many brochs required repair and some, like Dun Carloway, Midhowe and Gurness had failed rather dramatically. These were repaired or rebuilt within their original

broch tectonics. The cause of the failures was probably masonry creep under significant dead loading.

Finally, brochs were abandoned following a primary-use period that could have been as short as a century and remained out of formal use for a further period of up to another century, on the evidence, mainly of sediment formation from Thrumster, Borwick, Rhiroy, Beirgh, Bharabhat and Dun Troddan (see Chapter 6 Thrumster)<sup>203</sup>. Despite these and other examples of discontinuity in deposit formation, the long duration continuous use model (LDCU) is generally accepted. The Long Duration Continuous Use hypothesis is unsustainable and assertions that brochs remained in continuous use for a millennium or more are not well founded in the evidence.

Following the initial hiatus, on the east coast and in the Northern Isles the dilapidated and often truncated remains of brochs were refurbished and used as 'citadels' within walled townships. This period of reuse has given rise to the greater majority of the artefact assemblages recovered from brochs. This is most probably the period in which most broch towers were truncated and remodeled with secondary entrances forged through the stairfoot area and, progressively many of the stacked voids were sealed off or refashioned for alternative, non-structural uses.

In the west and the Hebrides, the cultural equipment of the period, such as the 'broch' pottery, was in extensive use, but the brochs were either abandoned or perhaps, like Dun Vulcan, continued intermittently in their traditional use (Parker Pearson and Sharples 1999), more likely the former. Settlement concentrated in the coastal *machair* zone within small groups of wheelhouse-type structures and a wealth of artefactual material (Barber 2003) but little or none even on reused brochs.

## Artefact chronologies

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<sup>203</sup> In addition Petrie, wrote in 1890 of artefacts recovered from amongst the debris within the broch and argued that they had fallen from original positions in the upper galleries (an interpretation cited by MacKie without demur; MacKie 2002, 262). The collapse was probably diachronic and the artefacts represent a transient reuse of the interior during the period/s of its accumulation.

In discussing the chronologies of broch towers, and their cognates in this thesis, the dates from artefact studies have been largely ignored. Any artefact<sup>204</sup> found in deposits on a broch site post-dates the monument's construction. Unambiguous dating evidence can only be derived from those, sadly rare, instances in which the taphonomies (deposit formation processes) of the artefact containing deposits are clearly understood and in which the artefact-containing-deposit clearly interdigitates with the fabric of the monument. Of course, art-historical dating of objects may suggest a more or less robust chronology for the artefact outwith its depositional environment (see for example Heald on Doorknob Spear Butts or Newman on Ring headed Pins and both on earlier work) but the question of their relationships with the structure remains moot. However, many Scottish Iron Age artefacts are chronologically insensitive and the writer has argued (Barber 2003, 126) that the dating of sites from pottery typologies fails to reflect the sites' stratigraphies even on well stratified sites. On the whole, artefacts currently make a small and uncertain contribution to the dating of broch construction and modification and are unlikely to do better in the near future.

## Monumentality and mutable monuments

It has been argued above that brochs are not *Monuments, sensu* memorials and the large number of surviving brochs would militate against an attribution of *monumentality* because it is hard to envisage a person or event that required more than 600 memorials, all identical save only for scale, and was then wholly forgotten. It may be that Armit's definition of monumentality (see Taxonomies of brochs (*sensu lato*)) could be better expressed in terms of the cost of building per unit area of useable space provided. The principal difference between a hut circle and a broch tower of equal internal diameter, of say 10 m, is the fact that the latter would require more than 10 times as much material and cost up to 50 times more to build<sup>205</sup>. The

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<sup>204</sup> Ignoring pre-existing artefacts *in situ* under the monument.

<sup>205</sup> The ratio of enclosed floor area (in m<sup>2</sup>) and the cost of building (in kWh) or its proxy, the built mass of the monument (in tonnes) would provide a useful measure of the scale of aggrandisement. The unit of measure (tonnes/m<sup>2</sup>) could be called a 'broast'.



primary desired outcome of construction is the creation of enclosed spaces and the conspicuous expenditure of resources for no net gain in the enclosed space can only be explicable in terms of social advantage, presumably that which derives from personal aggrandisement. It is concluded that brochs are examples of structural aggrandisement and that such monumentality as they possess is of the type described by Riegl as 'age value'.

Drystone built structures are highly mutable, as the analyses recorded in the case studies demonstrate (Chapters 6 & 7). In broch towers, mutability is a consequence of their building technology, not of their design concept. It proved difficult to identify even significant masonry alterations in the broch's wallfaces and, as noted earlier, too easy to be misled into identifying superficial variations in wallfaces to support a particular interpretation. Masonry differences in wallfaces may prompt the suspicion that alterations have taken place in broch structures but additional evidence will always be required to confirm that this is so.

The architect John Hope has drafted notes on broch towers from a tectonic, use-of-space, perspective and whilst none of these has been subject to peer review, or indeed been published as coherent documents, Ian Armit has, to a degree, founded on Hope's views (see especially Armit 2003, 73-6 and see discussion of its elements at pages 80, 261 and 198). It seems a little cruel to critique an unpublished theorem but given that it has been secondarily published, it cannot simply be ignored. Armit's interpretation of Hope's work as set out in the cited text; if either author is misrepresented here, this writer apologizes. Hope's suggestion that the roof sat within the outer wall would necessitate a drainage system to remove water from the wall thickness and Armit's explanatory figure (Figure 31 Armit 2003) has been shown above to be unsupported by the evidence. Hope's suggestion, via Armit 2003 that the stacked voids are part of a ventilation system is similarly dismissed above because the coincidence of the voids with the points of greatest compression stress is better explained by the need to cope with this resultant strain, especially as numerical analysis has shown above that the inner wall is almost always close to or above worrying levels of ground loading. Hope's placement of domestic activity at the first-

floor level is unexceptionable, but the evidence on which Armit founds his support for this view has been dismissed as tenuous (see page 198, above).

Taken in the round, Hope's interpretation of the structure and function of brochs is vitiated by his uncritical acceptance of the prevailing views and the prevailing paradigm, which ultimately render his structural analysis misinformed and leave his conclusions unsupported by the field evidence.

## The broch-like monuments

Of the roughly 600 brochs and probable brochs in the NMRS records the attribution of broch tower has been restricted to those examples identified as such by MacKie to which the writer adds Thrumster, Old Scatness and Alltbreac, which excluding the semi brochs, leaves a total of fewer than 80. The remaining c 500 are in the main rounded mounds with few or no distinguishing features. This may lie behind Scott's suggestion that brochs existed in three size varieties (Scott 1947, 10) the first roofed at 1.5 to 2.4 m, the second roofed at 4 m and the third and smallest group, roofed at 6 m or above. The ubiquity of proofs of tower structures amongst the better preserved of MacKie's putative broch towers (Chapters 6 and especially 7) provides a strong counter to Scott's proposed scheme. So strong, in fact, that the onus is now on those who believe otherwise to demonstrate that the less well preserved remains are not in the main broch towers. It is of course likely that some of them are monuments of another character including duns, small forts massively built roundhouses, or Simple Atlantic Roundhouses (e.g. Bu, Quanterness, Tofts Ness, St Boniface, Howe (Phase 5) and Crosskirk<sup>206</sup>) but any assumption that they are all smaller structures is not warranted.

A reading of the dating evidence suggests that these monuments are in general earlier than broch towers, which is why the teleological assertion is made by ScARF that these are an evolutionary stage on the way to broch tower development (Chapter 2). Whilst not an ancestral form to the broch tower, these monuments may highlight the

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<sup>206</sup> See Table 1, Chapter 4 for references and radiocarbon dates

emergence of a social drive to structural or architectural aggrandisement at the start of the first millennium BC and in that sense, may indicate the opening stages of the social impetus that finally gave rise to tower building<sup>207</sup>.

With others<sup>208</sup>, the writer has excavated at Nybster and Whitegate, in Caithness and neither of these is a broch tower. Both now comprise inner and outer wallfaces with rubble and soil infill, at Nybster and beach cobbles, at Whitegate. At best, these monuments may have aped the form and proportions of broch remains. They have as much in common with broch towers as bank facades have in common with Greco-Roman temples, or as bankers have with the integrity their impressive facades are meant to imply. To these sites may be added those genuine broch remains that were converted to later, possibly Pictish use, like Clachtoll, whose façade is said, albeit on no tangible evidence, to have been re-erected by Picts, and like the many eastern and northern brochs subsumed in later villages.

Broch towers are a Lamarckian development arising without phylogenetic precursors from a background of modest drystone structures little more than aggrandised hut circles. Broch towers are not a gradualist Darwinian evolution from some nominal antecedent that might be found amongst the broch cognates. Following publication of Armitæ's axiomatic taxonomy of such structures Gilmour undertook a PhD study that touches on the matter (Gilmour 2000), elements of which he published (Gilmour 2002, Gilmour 2005). Based on these and other relevant texts it is concluded that the absence of a competent phylogeny and process taxonomy of these monument *vis a vis* the broch tower is attributable to two factors. The first is that they are not a

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<sup>207</sup> This may have begun earlier, in the terminal Bronze Age/Early Iron Age, when other evidence for structural aggrandisement may be indicated by the divergence of hut circle forms, with those of the far north east thickening the penannular wall at the entrance area, in a crab-claw and in Perthshire, hut circles were sometimes built side by side and enclosed within a shared outer wall (Rideout.. Rideout, J S (1995). "Carn Dubh, Moulin, Perthshire: survey and excavation of an archaeological landscape 1987-90." *Proc Soc Antiq Scot* **125**(1): 139-195.).

<sup>208</sup> Nybster and Whitegate were excavated under the direction of Drs Cavers and Heald who, together with the writer and Paul Humphreys and advised by Dr Jon Henderson and Dr D Theodossoloulos, formed a Caithness research group and excavated at these and other brochs in the north east of Scotland. The writer has taken part in excavations on Nybster and Whitegate and has led excavations on Keiss Harbour, Keiss Road and Thrumster as part of the Caithness group.

coherent set or group of sets; they share a common aggrandising response but not a common structural phylogeny. The second, that brochs, are a Lamarckian developmental eccentricity and thus even further distanced from the remainder of the group. This thesis has focussed solely on the broch tower and concludes that the majority of the surviving broch remains should be accepted as broch towers until proven otherwise by survey analysis and excavation. For the remainder of the monument types in the Armit axiomatic taxonomy, they share a basic drystone building technology, curvilinear plan form, occasional aggrandised appearance and little else.

## Social contexts

### Brochs in anthropology

The vexed question of social organisation (Renfrew and Bahn 2012, Chapter 5) can be approached from a top down, anthropological theory perspective (Service 1971) or from a bottom up, identity theory perspective (David and Wilson 1999, Thomas 2000, Marti-Gradel, Deschler-Erb *et al.* 2002, Henderson 2007, Ousterhout 2008, Gilmour 2000), but it is impossible to reconcile these two approaches in practice. Believing that the selectively sampled surviving remains of the past are in general more susceptible to generic analyses than particular analyses on lifetime scales, the writer has opted for an anthropological theory approach, following the seminal work of Elman R Service<sup>209</sup>. Some of the criticism of this work aligns with the general decline in the popularity of evolutionism theory in the Americas (for a review, see Sanderson 1997, 98-100). Nonetheless, it remains the framing work for the field. Service identified four principal social organisations, the mobile hunter-gatherer groups (or bands), segmentary societies (or tribes), chiefdoms and states. Each is more complex and more highly organised and more stratified than its predecessor type, contains greater numbers of members and is more capable of creating architectural monuments (Renfrew and Bahn 2012, 172). While Service subtitled his

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<sup>209</sup> Renfrew and Bahn have produced a simplified digest of Service's work (*ibid*), from which the writer has further simplified and abstracted the model presented here.

book –an evolutionary perspectiveø it is helpful to know that he requires a special redefinition of evolution to sustain this position and he acknowledges that his –evolutionø is both directed and sequential, i.e.

The taxonomy used is not phylogenetic, for the concern is not with the historic or genetic relationship of the diverse forms, but rather with their structural-functional differences in order of appearance, no matter what their relationship or the line of descent to which they pertain.ø (Service 1971, 5)

Thus, his system is an axiomatic taxonomy, akin to the Armit model. Service believed that while it is possible that a stable social group, growing in size and complexity may pass through the four stages, sequentially, this is not a necessary precondition and more complex societies may emerge from apparent chaos without passing through the proposed sequence of social organisations<sup>210</sup>. Indeed, and possibly uniquely, Service acknowledges that many of the societies catalogued in the *Human Relations Areas Files* do not have even an aboriginal social organisation and remain or survive as chaotic groups comparable, for Service, with a displaced persons camp (Service 1971, 9). These social groups are here termed –Residualø and are envisaged as the survivors of the collapse of an emergent social organisation, rather than as ultimate autochthonies yet to aspire to social organisation of whatever form. The small-scale reuse of west coast brochs after their primary abandonment by peoples Curle described as –the fugitive and the vagrantø is possibly evidence of the socially residual.

Armit proposes a number of systems of heritability of land (Armit 2005b, 129) which he considers under two generic headings, which he terms, divisive inheritance and redistributive inheritance. He finds on Thomas Charles-Edwardsø 1972 for his inspiration albeit that Charles-Edwards notes that the hide was, at least originally, the landholding expression of a particular form of kindred, one whose relevance to Iron Age Scotland remains to be explored (Charles-Edwards 1972, 3). Accepting this

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<sup>210</sup> Perhaps akin to Clarkeø's unkind suggestion that Australia went from barbarism to decadence without passing through civilisation.

source as a general inspiration rather than a specific template, Armit's challenging paper retains its relevance. Paradigmatically, Armit assumes the Long Duration Continuous Use model for settlement in and on broch towers as well as in and on wheelhouses both on his own part and by citation on the parts of others, e.g.

– it must be remembered that many Atlantic roundhouses continued to be occupied, some in highly modified form, for many centuries. (Armit 2005, 132)

– Niall Sharples (this volume) stresses the continuity of individual Atlantic roundhouse settlements over many centuries, implying that these settlement patterns were stable and long-lived. (Armit 2005b, 134)

Thus, the meat of Armit's paper is conditioned by the LDCU assumption, which may have seen continuous settlement from the third century BC to the 9th century AD. This thesis has argued that there is no evidence to support the LDCU assumption for broch towers and that such evidence as exists and bears on the subject rather emphasises the contrary view. Abandonment episodes have been demonstrated from the well excavated sites, of which the most important is the hiatus following the original construction of the broch towers that predates a sequence of artefact-rich deposits associated with intermittent refurbishments of the broch tower in ways contrary to the original tectonics of the structure. This has been demonstrated both in the sedimentary sequence, the construction history and in the pattern of radiocarbon dating for Thrumster broch (see Appendix\_Thrumster, but note discussion on the relevance of the Bayesian models deployed)

Armit's 'redistributive inheritance' category is, in fact an intergenerational version of runrig agriculture, a system by which communal lands were re-divided at intervals between community members, according to their needs and capacities. As Graeme Whittington's review of the subject shows, there were many variations on this simple theme (Whittington 1970) and Armit's conceptual model could be developed to encompass that variability. Runrig operated from an immemorial time to peter out between the sixteenth and eighteenth centuries in Scotland. In Lowland Scotland it survived in places into the seventeenth and early eighteenth centuries and was widespread in the Highlands into the eighteenth century (see Dodgshon 1975 re

Roxburghshire and Gray 1952 for the Highlands ). Armitø's model lacks the sophistication that the operational demands of such a system place on landscape and people. More importantly, the Runrig system, under the Clan system, was divorced from the issue of inheritance; runrig tenants, sometimes directed by their tacksman, subdivided the land, as required while ownership of the land was heritable under male primogeniture and the one system did not materially influence the other. Land management systems need not be indicative of heritability of real estate albeit that the contrary belief permeates Armitø's paper.

His ÷divisive inheritanceøsystem is mirrored in the consolidation of runrig at the time of its transition to currently normal tenancy types. Once the idea of common rights of ownership had spread sufficiently in the post-medieval period, the partibility of landholdings rapidly became such that a person could inherit a significant acreage in so many separate packages that no part of it was larger than a small garden. The Congested Areas Boards assisted in the re-division of such lands (Micks 1925) while the profession of ÷land surveyorøevolved to service these and other cartographic needs in the landscapes of Ireland and Scotland (O'Cionnaith 2011). The sort of heritable landownership assumed in Armitø's paper is a modern anachronism, but a comparable system might have evolved in the Iron Age.

As a first experiment in mind-mapping monuments to landscapes and both to patterns of settlement, changing at least generationally, Armit 2005b is a good starting point. It is likely that medieval and post-medieval settlement in Scotland has many practical lessons to teach about land holding, land use and in later periods, land ownership. Armitø's relatively static framing differs from the dynamics of modification, rebuild and reuse of broch towers discovered in this thesis which calls for a more mutable and dynamic inter-generational socio-economic settlement model and abandonment of the LDCU assumption.

### **Brochs, an historico-anthropological model**

It is proposed that the brochs were built by the citizens of farming republics (Chapter 4), segmentary societies, probably on the threshold of chiefdoms. They were capable of large construction projects but probably did not have long term stability and their

power and significance waxed and waned as first one and then another came to local dominance while none acceded to outright regional power. Unable to support a full complement of their own professional classes, the republics relied on access to professionals from other, possibly larger communities; services including those of the genealogist, historiographer, medic, metallurgist and constructional specialists, amongst others. The territory over which the farming republics extended included the whole of the Atlantic Province. No evidence survives to indicate differentiation of the RSM across the entire territory.

It is probable that the brochs were built before or around 300 BC, on the basis of a reading of the available evidence; vitiated by the imprecision of the radiocarbon method. Abandoned after a period of primary use, the east coast brochs were brought into reuse by an institutional-chiefdom based society which based fortified settlements on and around them. This is likely to date to the interval 200 BC to 200 AD based on artefact chronologies of low reliability. This society existed only on the east coast and in the Northern Isles. In the west, brochs fell into desuetude and at best were reused by squatters and while it is possible that the broch building communities continued to exist, it is not impossible that they were reduced to Residual Social Group status, which would explain the loss of the brochs from myth, tradition and ethnohistoriography.

Finally, and probably around 400 AD, surviving northern broch remains were spoliated by emergent, probably Pictish, social groups and new monuments, massively built but structurally naïve and not tower-like, were sometimes built in imitation of the reduced remains of the extant brochs.

The existing (2012) paradigm imagines broch towers being built in two dramatically different social contexts, as standalone monuments in the west and as the centres of townships in the east and north, this dichotomy is unsatisfactory and antithetical to the RSM model's canonicity. It is more plausible, and supported by the evidence provided above, to argue that all brochs were built as standalone monuments over the whole broch range (the 'Atlantic Province') in the third century BC and that the loci of broch towers in the East and North were sometimes reused in a new and vibrant



cultural efflorescence a century or two later whilst those in the West continued in solitary use. Over all the range, however, an hiatus existed between the unknown primary use of the towers and their subsequent reuse as domestic residences, citadels in walled villages and quarries for the construction of small scale developments of domestic housing. This hiatus is represented by sterile deposits and by soil development on several sites, Dun Toddan, Thrumster, Dun Rhiroy, etc, and is only the first of several interruptions to settlement and other uses on deeply stratified sites. Broch tower excavations offer no evidence for continuity of settlement, and thus do not support the LDCU hypothesis. Broch loci were used intermittently as their social contexts demanded, until finally, subsumed in their own detritus the brochs were built over and the broch was forgotten.

The scale of the expungement of brochs from memory is comparable with the Roman *damnatio memoriae* (Chapter 2). Almost nothing of them is remembered in folk or polite memory<sup>211</sup>. Few or no myths are associated with them and the names by which they were known to their users have been lost to us. It seems likely that the mnemosac, the package of cultural beliefs and practices within which the broch tower functioned was lost or expunged very soon after their construction and whilst a zeitgeistic consciousness of their once great significance outlived them, their cultural significance had reduced to nothing. Loss of social continuity over the broch range with the eastern and northern provinces being subsumed into a new cultural *milieu* could have eclipsed and marginalised the western farming republics and the latter may have preferred rural obscurity to subordination within a new polity.

### **Brochs, issues of duration**

In Chapter 4 the forms of social organisation likely to exist in late first millennium BC Scotland have been discussed (and see above also). Iron Age society in the period comprised a social network based mainly on the management of cattle as a

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<sup>211</sup> See Appendix Memory Papers 1 and 2 for text of two peer reviewed papers on the subject of brochs and memory prepared as part of this thesis and in press at the time of submission. There is insufficient space in the main text for a more developed discussion of the subject and the reader is referred to the relevant appendix.

capitalist enterprise with arable agriculture providing mainly a subsistence element in the economy. An interlocking network of social contracts ranged up and down the social pyramid with primary investment and revenue returns based on labour-provision, agricultural produce and mainly on cattle.

Into this socio-economic network of relationships and obligations the inspiration to build a broch tower was dropped. The non-trivial costs could probably be met in part from labour obligations of clients and in part financed directly by the payment in cattle of the broch commissioner, or resource providers. Thus, it entailed loss to the ruler by expenditure of both revenue and capital, but it would have enriched the recipient clients. The broch building project thus, directly affected the economic relationships between the main social protagonists. The conspicuous expenditure of capital in such a society was potentially destabilising and, even without an external stimulus, it could have terminated the broch building episode.

Thus, it is suggested that brochs were built in a short period and were soon abandoned, not because of external aggression but because the practice was economically unsustainable. The Pictish reversion to broch sites and their spoliation of the image of the broch may represent their aspiration to hark back to a, by then, heroic age of isolated warrior aristocrats (real or imagined) in their massive towers.

The evidence from the large Orcadian and north eastern mainland sites suggests that the broch's structural remains were substantially reduced prior to the main phase of secondary occupation, with remodelling of the broch remains in the 200 BC to AD 200 interval. The construction of a secondary village in and around the broch may imply a modification to the social system in which institutional hierarchies possibly with some permanent administrative staff replaced their tribal and familial antecedents. The advent of institutional hierarchies on the northeast coast and in the Northern Isles created a cultural efflorescence, with large numbers of artefacts and ecofacts recovered from the relevant sites together with, later, some exotic imports, mainly from the Roman world. Meanwhile on the west coast and in the Western Isles the traditional and primary relationships persisted in farming republics and brochs remained largely isolated structures with relatively poor material assemblages.

MacKie identifies the late third, early second century BC as his age of the brochø (MacKie 2008 , 261) but it is suggested here that it may be the age of the spoliation and substantial reuse of brochs rather than the age of their initiation. It is a characteristic of living systems that stimuli operate within negative feedback loops<sup>212</sup> that limit or terminate their action. The broch, viewed as a Popper world 3 system, a product of human ingenuity was self-limiting in its own structure<sup>213</sup> and formed part of a self-limiting cycle in the social-economic system that was its genesis<sup>214</sup>.

## Brochs for this and future generations

The cultural value of heritage assets is measured in terms of the information they can convey to this and future generations about the human condition at points in the past (see for example ICOMOS 2013, UNESCO 2013<sup>215</sup>). Broch towers are large complex monuments (LCM) and their remains lie at the nexus of a series of dynamic process systems, including the dynamics of formation, use, deformation and intervention. Their interaction is responsible for the extant remains of the monument and for the monumentø's current cultural value. The current condition of the monumental remains under intervention is also a consequence of the interactions of the dynamics of their survival and the intentions of their intervening conservators, using the latter term in a very broad sense.

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<sup>212</sup> Without negative feedback our first nerve transmission would be our last. It is necessary to switch off nerve stimuli to muscles once used or they would simply lock in place and never move again. Virtually all living systems are of this type.

<sup>213</sup> Its size is restrained by the physical limitations arising from the design concept at its upper and lower extremities.

<sup>214</sup> Many economic mechanisms are thought to be controlled by negative feedback, of which the supply and demand cycle is a good example.

<sup>215</sup> Academic discussion of the concepts has rather lagged its development in legislation and regulation and the writer has founded on this tested body of knowledge rather than on emerging discourses elsewhere.

The meaning of the term *Monument* has been considered in Chapter 2<sup>216</sup> and here we are concerned with monuments visible at ground surface that have now acquired Riegl's *age value*. Considered as structures, it is legitimate to distinguish between living and dead monuments. Living monuments are those that could conceivably be brought back into use, original or an alternative use, without doing violence to the original and authentic fabric of the monument. Dead monuments, conversely, cannot reasonably be brought back into use. Clearly the boundary between these sets depends crucially on *reasonability* which in this context must subsist in the scale of the impacts on the residual cultural value that the proposed reuse would occasion for the monument.

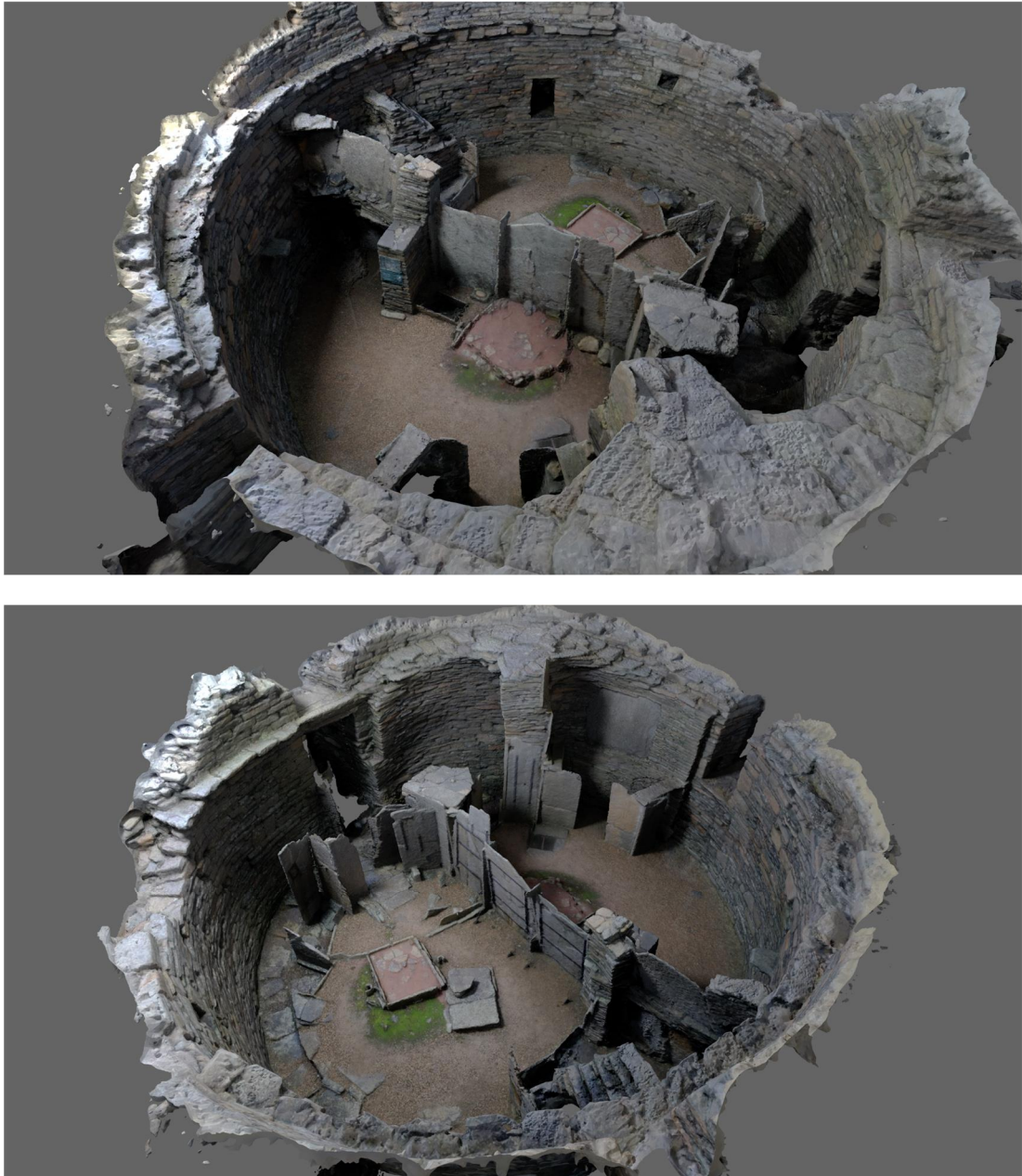
In this framework, brochs are dead monuments and it is improbable that any extant example will be proposed for reuse, other than as a touristic attraction. That being the case, interventions in brochs are primarily for academic study (see, Parker-Pearson and Sharples 1999, for example) or as a preparation for public presentation (most commonly at Properties in Care, i.e. in state ownership) or both. Victorian and more recent interventions in brochs have obscured some of the evidence for the operation of these dynamics (see Smith Forthcoming, re Clickhimin; Veloudis 2013-14, re Clickhimin, Mousa, Gurness, Midhowe and Carn Liath, or MacKie 2002 & 2007a and 2007b re Carn Liath and many more). The separation of archaeological from architectural inputs in the conservation of the great northern brochs (Hedges 1987, pp) was not ideal and certainly falls far short of the requirements set out in ICOMOS 1993, section 5 (see Feilden 2003, 189 *et seq* for discussion).

Riegl's concept of *age-value* (Riegl 1982) or the aesthetic sense of the antiquity of a place, is appreciable by all and more accessible than other, ideal valuation systems, because, he argues, it;

it possesses universal validity. It rises above differences of religious persuasions and transcends differences in education

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<sup>216</sup> *It* a distinction is made between memorialising structures, like a cenotaph or a triumphal arch which are here written of as *Monument/s* and other heritage assets, visible to the unaided human eye at ground surface to which the legalistic<sup>216</sup> or conventional term *monument/s* is applied. Chapter 2



**Figure 180** Three-dimensional representations of the current state of Midhowe’s interior. Prior to its ‘excavation’ in the 1930s no human being had ever seen this monument as the unitary structure now presented to the public (© AOC Archaeology Group Image generated by G Cavers).

and in understanding of art. And, in fact, the criteria by which we recognise age-value are as a rule so simple that they can even be appreciated by people whose minds are otherwise exclusively preoccupied with the constant worries of material existence.ø(Riegl 1982, 33)

In the UK, conservation of ancient monuments for public display is generally motivated by this aesthetic form of age-value but, this is very vulnerable to zeitgeistic influence and it leaves lesser monuments and most sites at a distinct disadvantage. Its treatment of the cultural value of monuments falls short of the ICOMOS Burra Charter process (ICOMOS 2013) which represents current best practice. Riegl's criterion is 'architectural' in its appeal to aesthetics, but for archaeologists, it is an inadequate basis, taken in isolation, for assessing cultural value.

## Dynamics of formation

In Chapters 5 through 8, the current state of Large Complex Monumental brochs has been discussed and the formation and deformation processes of their surviving remains have been deduced from those remains. Taking Midhowe as the exemplar (Figure 180), the result of these processes was the creation of a 'cumulative monument' that arguably had not existed before about 1933. This single structure, demonstrative of two millennia of development and decomposition is an artefact of the early 20th century. As a heritage asset, it is false and misleading. Its elements are authentic but their aggregate is not authentic; it is a chimera<sup>217</sup>. As presented on site and in the extant literature, the remains at Midhowe (Figure 180) are treated as a single conception which continued in use over a period of many centuries, largely unaltered and this is certainly misleading, as is the LDCU proposition that both underpins it and is underpinned by it. Extending Riegl's position, having created the age value of Midhowe and now it is now valued it for its possession of age value.

However, while the aggregate of the monument's elements, as currently presented, is inauthentic and misleading, it does faithfully represent an outline of the cumulative intermittent, natural and anthropic processes it underwent for more than a millennium. The demonstration of this train of processes, its *chaine operateire*, may

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<sup>217</sup> From Greek mythology, a chimera is a fire-breathing female monster with a lion's head, a goat's body, and a serpent's tail, this term is used to characterise a monument comprised of asynchronous parts.

justify the conservation of an inauthentic chimera, but only as long as supporting information makes clear the true nature of the beast.

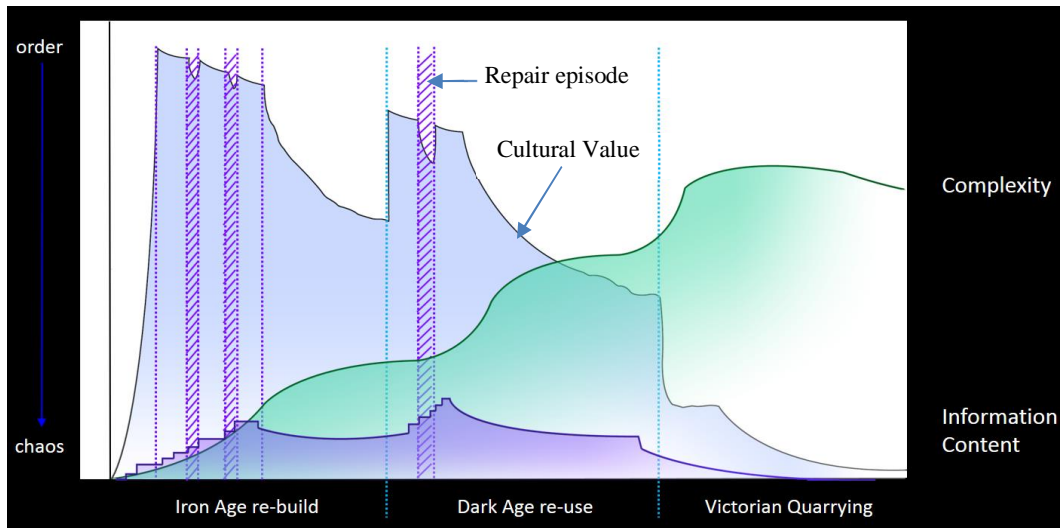
## Dynamics of Decomposition

Structural decay probably follows the normal decomposition curve for most materials, which is a negative hyperbolic curve<sup>218</sup>, the 'entropic curve' but this can be accelerated by human interventions and indeed it can be delayed, halted or reversed, for example by repairs or burial. If this principle is applied to a large complex structure that has undergone some repair and then perhaps some rebuild before a final near total destruction by quarrying, the resultant entropic curve would approximate to that illustrated in Figure 181.

A curve representing complexity, the inverse to the signal to noise ratio of the monument's information content, has been overlain on the entropic curve and this generally increases non-linearly over time. Also represented is the information content, which is a proxy for Cultural Value (below), and this waxes and wanes as ordered information content increases or decreases according to circumstance, but defaults to progressive reduction over time respecting the punctuated negative hyperbolic decay curve. The second law of thermodynamics ensures that all hoped that the rates of entropic loss in 'undisturbed' monuments are generally very slow. However, 'undisturbed' in this context really means free from direct human intervention. It does not consider disturbance from gradual soil processes, geochemistry or damage from rooting vegetation or burrowing animals. Furthermore, the accelerated rates of decomposition following intervention in *in situ* sediment continue to lose information are not necessarily slowed, much less halted by reburial (Reynolds and Barber 1984, Caple and Dungworth 1998).

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<sup>218</sup> The natural decay curve is a proxy for the Second Law of Thermodynamics which postulates that entropy maximises over time as order trends to chaos.



**Figure 181** The cultural value curve increases at build and following repair and rebuild episodes, but generally follows a negative hyperbolic curve (the standard decomposition curve) over time. The information content curve waxes and wanes depending on inputs and subsequent losses and the complexity of the system – here a proxy for the noise-to-signal ratio – increases with time.

Large Complex Monuments (LCMs) with complex biographies that may interleave natural and anthropic deposits and structures are inadequately represented by the exposition of a single phase. If, in addition, the single phase exposition entails the loss of the continuity of the monument's biographical *chaine operateire* it should not be undertaken lightly, or perhaps, not at all. The consequences of interventions in LCMs for their cultural values, expressed as proxies for their information content have been set out briefly in Appendix Interventions, q.v.

Defining 'significance' *sensu* cultural significance, as:

Significance is a synthetic representation of the identification, assessment, judgment and social validation of past and present social meanings attributed to heritage areas (Zancheti, Hidaka, Ribeiro, & Aguiar, 2009).

Zancheti and Loretto emphasise the need to retain the original and authentic fabric of a monument, which remains the *sine qua non* of cultural value:



Significance was viewed as a dynamic concept open to additions, subtractions and superposition of meanings. However the objectivity of the attributes of this object [HUL or LCM] should not be denied because it is clear that the attributes, material and nonmaterial, convey the meanings between generations. In a discourse on the significance of a complex urban heritage area the gaps in the meaningful attributes may be filled by records of memory, so making the discourse intelligible. *The interpretation of the HUL by people however will continue to be dependent on integrity of the attributes. The records of memory are not sufficient to recompose the integrity of the attributes to express the significance of the past and the present, and leave open the possibilities to the interpretation of the significance in the future.* (Zancheti & Loretto 2012, 10: emphasis added by this writer)

The appropriate framework for exploring the cultural value of LCMs (and HULs) may best be found in the *Operational Guidelines* to the UNESCO World Heritage Convention on Cultural Landscapes. Like HULs, LCMs are by definition anthropic landscapes. Following the initial build, the LCM becomes a cultural landscape because in its subsequent development it illustrates;

the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal. (UNESCO 2013, Article 47)

Considered in this context, the sequence of the processes involved in the formation of, LCMs like brochs are the responses of a human society in a developing relationship with the constructional envelope which the monument is and from which, it becomes. The conservation of Large Complex drystone-built Monuments should therefore be framed in the context of cultural landscape studies.

However, the broch tower as a single, if large and complex monument differs from monuments whose complexity lies in their multiple parts. The broch tower was conceived as a single unit and built to a standard formula, constrained by design limitations, stability issues and cost. Its engineering is crucial to its understanding, especially where it has been further complicated by later alterations. For this reason,

its conservation should facilitate retention of its original and authentic engineering. Theodossopoulos suggests that:

– the only way to establish the original scheme is by critical study of *in situ* evidence. The material can be easily dislodged and there is usually lack of historic memory about their technique or architecture. The restoration priorities are therefore didactic (provide an idea of the original impression) and safeguarding. (Theodossopoulos 2012, 14-15)

The treatment of broch remains in state care is wholly compliant with that position, albeit that recording and reporting on works undertaken fall short of the ideal. Conservation of broch towers, in contradistinction to didactic presentation and preservation, requires that we understand their past and current mechanisms of structural stability. As noted above, creep is a major challenge and some of the nation's finest brochs are slowly decomposing even now. Interventions to halt this should not be taken at the cost of occluding their original and authentic engineering configurations. Thus, it is more important to include an architectural engineer in the conservation than an architect and essential to have an archaeologist on board for all discussions.

## The Mind of the Builder

It has been shown that the mind of the broch builder was first engaged at the level of the commissioning agent, a petit-ruler, perhaps a *primus inter pares* amongst the local farming republics. In a mnemosac spirit of self-aggrandizement, s/he sought to architecturally engross their principal structure. Fortunate or rich enough to have access to a master mason of intuitive genius, the perceived social need was converted to a design brief. This necessarily included meeting the major structural challenge, that of the management of self load. Relieving structures used over lintels in more modest buildings were engrossed and over the entrance allied to differentiated lintels, with a weight relieving void above. The relationship between the inner radius and all of the other plan dimensions was set by making it 50% of the outer radius. The inner wall was a vertical cylinder held in compression, and thus rigidized, by the inward

lean of the outer wall. The batter angle of the outer wallface, in combination with the internal radius determined the height and all other related parameters of the structure and this was a vital consideration because it facilitated costing the brief and marshalling the resources.

It is hard to escape the conclusion that a single designer, or design team, produced the initial broch. The simplicity of its conceptual design, based on a two parameter modulus and a rule-set facilitated its dissemination while the physical limitations, illustrated in Figure 179 ensured its canonicity. The design is brittle and fails with even small deviations from circularity, horizontality and verticality in critical elements. Mutation was thus positively discouraged and the ur-broch form of the RSM was the disseminated norm.

It is depressing, if honest, to have to admit that there is virtually no evidence to guide us to the function of the Ur-broch. Its large scale and extraordinarily expensive construction suggests that aggrandizement on the scale of the Italian Torri lies at its heart; the venal posturing of small and frightened men, perhaps. Its lack of obvious functionality and its apparently wasteful encapsulation of a very large void would in contemporary society mark it out as a public or religious structure, and indeed such it may have been.

The mind and ambitions of the successive re-builders and re-users of brochs are altogether more quotidian. Attracted by the locus and by the free supply of stone and constrained by the existing masonry remains, they squatted within or built slighter secondary structures in and around, and finally over the brochsøremains. Their modifications were predicated in large part by the extant masonry and their modifications of it were patterned in parallel with it. Finally abandoned before the arrival of the Norse, the ruins were refashioned by fugitives or used as burial knowes by those not yet brought to heel by Christianity. But long before then, the broch and its genesis had passed from cultural memory.

## In memoriam

In excavating and surveying brochs it is not uncommon to encounter arrangements of stone or packings in walls and wall-cores or arrangements of structural elements that are immediately redolent of the hands that built them. These can be moments of strong emotional discovery when across the temporal divide a contact is forged between the builder and the archaeologist with an immediacy that bypasses time, space and language. These magnificent monuments were built by men and women who were probably deemed unfit to enter them. The great and good of the day enacted their social schemes, benevolent or self-interested, cruel or kind, according to their natures. And now, they and their schemes are forgotten; their garlands are dead, their Gods have fled. Historians necessarily concern themselves with princes and kings and their ilk but archaeology and forensic architecture must always concern itself first with the physical remains of the people. It has been a great pleasure to try to approach the minds of the broch builders and to listen to their contribution to the murmuring of the river of humanity as it flows from Eden to eternity:

𐌆 and I who hear the tune of the slow

Wear willow river, grave

Before the lunge of the night, the notes on this time shaken

Stone for the sake of the souls of the slain birds sailing.ø

(=Over Sir Johnø HilløDylan Thomas).

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