Digital Archaeology and the Neolithic of the Peak

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Abstract

A significant component of Landscape Archaeology is concerned with recognising human experience and activities at a number of different spatial scales. This study looks at how related areas of technology can be used to investigate these different scales of activity and experience, and how these can be integrated to capture potential synergies that exist between them. The technologies considered are Geographical Information Systems, Panoramic Virtual Reality (PVR), 3D virtual models, and interactive multimedia. Although each of these technologies have been used fairly extensively in their own right, there have been relatively few studies where they have all been applied together, to the same body of archaeological knowledge. In this study, all the technologies have been applied in the same context, which is the Neolithic of the Peak District, with particular attention focussed on the ceremonial monuments of the White Peak. This is mediated by three main case studies.

The first case study uses GIS based viewshed analysis to examine the distribution of the Neolithic burial mounds and two Henge monuments of the Peak District. The results of the analysis are discussed within the prevailing models of seasonal mobility, and also address issues of increasing scales of concern from the early to later Neolithic.

The second case study uses PVR to represent monuments and their landscape settings. In particular this technique is used in conjunction with some of the viewshed data created above, in order to create *embodied viewsheds*, as an alternative to the default presentational metaphor of the map.

The third case study uses the integrative potential of interactive multimedia to combine elements of the above, along with 3D solid models of a particular monument, the Arbor Low henge. These are presented within the context of a learning resource, demonstrating how these technologies can be used as

tools to facilitate learning in a constructivist environment, in which students are actively engaged in creating their own knowledge.

It is hoped that this study will be of interest to those researching the use of GIS, Virtual Reality and/or e-Learning in archaeology.

Chapter 1 - Introduction

1.1 - Introduction

The broad aim of this thesis is to address what appears to be a growing disjunction between two emergent strands of archaeological practice that have been developing over the last 15 to 20 years.

The first of these has been the emergence of Landscape Archaeology, which is part of the broader post-processual paradigm shift that has affected the discipline as a whole. Landscape Archaeology has a long history, with its origins arguably in the work of Crawford (1953) and Hoskins (1955). Although the term now defines a burgeoning sub-discipline, this is quite different from the situation 20 years ago. Up until the early 1990s, Landscape Archaeology was generally used as a collective term for a group of related methodologies. Many of these were survey based, typically deployed in contexts where excavation was not possible, due to reasons of cost or other practicalities (Thomas 1993). Since then, it has become a much more inclusive and holistic sub-discipline, concerned with scales of analysis that are broadly commensurate with the different spatial scales at which people's lives were articulated. An important component of this has been the phenomenological approach, which addresses how life was experienced by individuals or groups in the past (Bender 2006).

The second of these has been the effects of the Information Technology revolution, since the late 1980s. This has impacted upon virtually every aspect of archaeology, from data collection in the field, through to public participation in the discipline as mediated via the Internet (Lock 2003). Examples of IT use of within the discipline have been documented in a number of edited volumes (Evans and Daly 2006, Lock and Brown 2000, Reilly and Rahtz 1992, Wheatley et al 2000), conference proceedings from over 30 years of Computer Applications in Archaeology meetings, and occasionally in more general archaeological literature. This proliferation has been largely driven by the enormous increase in computing power, and relative decrease in cost over the last 20 years. With this has come a tremendous diversification in applications for desktop PCs – originally designed to run spreadsheets for accountants, they can now be used to play graphically intensive games, compose music and edit feature films. Part of this diversification in computing functionality has included the emergence of desktop Geographical Information Systems (GIS) and Virtual Reality (VR) applications, which until the early 1990s would have required dedicated high-end workstations, typically the preserve of academic institutions and specialist research facilities (e.g. Goodrick and Earl 2004). It is the use of these latter categories, along with interactive multimedia, that concern this study.

Although there have been significant developments in Landscape Archaeology on the one hand, and the use of GIS and VR in archaeology on the other, the two have not generally gone hand in hand, and have followed largely independent trajectories. This problem had been noted by David Wheatley in the early 1990s (Wheatley 1993). Many landscape and phenomenological studies have eschewed any systematic use of technology (Thomas 1993, Tilley 1994). Equally many developments in new technologies seem to have proceeded in at best a theoretical vacuum, or worse, have resurrected approaches that the broader post-processual movement have largely discredited (Wheatley 2004, Witcher 1999).

This has not been the case in all studies however. During the last 10 years, a number of authors have started to address this problem and have sought to unite the aims of theory, with the affordances of the available technology (e.g. Exon et al 2000, Gillings and Goodrick 1996, Llobera 1996, Pollard and Gillings 1998, Wheatley 1993, 1995, 2000, 2004, Witcher 1999, Rajala 2002, Trick 2004). This has involved providing timely critiques of previous work, and important theoretical contexts for future work to follow. This has applied both to the applications of GIS and VR within the discipline, in addition to the more generic uses of IT (Gidlow 2000, Huggett 2000, 2002, Tschan and Daly 2000).

It is within this context that this study has been situated. Building upon the important practical and theoretical considerations highlighted by the above authors, this study aims to integrate the potentially related technologies of GIS and VR, along with developments in interactive multimedia, and to apply these within an established body of archaeological knowledge.

Although largely a practical study in the use of interrelated technologies, these have been applied as an exercise in Landscape Archaeology, and so the issues prevalent in this discipline that are relevant to this study are considered next.

1.2 - Introducing Landscapes

Landscape Archaeology still uses many of the field recording techniques and procedures that it used 20 years ago or more. What is perhaps different now, is how the discipline conceives of the term *Landscape* itself.

1.2.1 - Conceptions of Landscape

> "A landscape is a cultural image, a pictorial way of representing, structuring, or symbolising landscapes." Daniels and Cosgrove, 1988: 1
>
> "Let me begin by explaining what landscape is *not*. It is not 'land', it is not 'nature", and it is not "space"'. Ingold 1993: 153

Landscape is not a word or concept that can be taken at face value. Before any exploration of how new technology can inform the study of prehistoric landscapes, it is necessary to qualify in what ways archaeologists conceive of landscape.

In attempting to define landscape as a concept, it is instructive to chart its etymology. The term landscape can be seen to have its origins in early Anglo-Saxon, analogous to the German *Landschaft*, referring to a small piece of cultivated land, arguably corresponding to a peasant's perspective (Bender

2006). The word fell out of use for around 600 years, and eventually became superseded by the term landscape, in the seventeenth century in Italy and the Netherlands. On its re-emergence, it had come to denote something quite different – a means of representation in the form of landscape painting.

Rather than just providing decorative images, post-Renaissance landscape painting became a new way of seeing landscape. In post-Renaissance landscape painting, landscapes became objectified, frozen in time, and presented as an ideological illusion (Thomas 1993). This was realised through the development of linear perspective, which became not just a technique, but a "means of revealing truth" (ibid: 21). Through this objectification, the viewer becomes detached from that in view, and the object/subject dichotomy is introduced. The observer now exists outside of the frame of reference of the painting, which is now quite literally the frame of the painting itself.

An important artefact of this post-Renaissance *view* of landscape has been the prioritisation of vision over the other senses, with the result that "more often we concern ourselves with *seeing in the world* rather than *being*" (Edmonds 2006: 5) This "primacy of vision", or *visualism*, became manifest in other aspects of Renaissance culture, importantly including cartography, and Cartesian philosophy. Vision became equated with consciousness and perception, and encouraged the empirical view of science, in which the rendering of something as visible also facilitated its being understood (Thomas 1993).

This concept of visualism permeates discussions of landscape, GIS based viewshed analysis, and Virtual Reality, and so will be discussed further throughout this study, as and when these topics are explored in greater depth.

The fact that visualism is a modern Western historical construct is demonstrated by ethnographic examples where people's conception of the world may be dominated other senses such as hearing or smell (Classen 2005, Feld 2005, Gell 2005, Rodaway 1994, Tilley 1994). This observation does not require the rejection of the importance of vision in perception of the world, just an acknowledgement of its context (Edmonds 2006, Miller 2000). The notion of the "Western Gaze" encompasses not only the primacy of vision, but also a view of the world that is determined by class, gender, and is ego-centric (Bender 2006, Thomas 1993). It is a view that reifies the distinctions between culture and nature, with culture as the male gendered object, and landscape as the female gendered passive subject.

It is argued that this new perspective on landscape also led to its commodification, and a move away from traditional patterns of tenure. It is this primacy of vision, commodification of landscape and birth of capitalism that Thomas has described as the "politics of vision" (1993: 22). The values enshrined in this new way of seeing have been the subject of discourse by art historians from Ruskin, through to Williams, Berger and Clark (Daniels and Cosgrove 1986). Through time, the conception of landscape as a noun, a representation, changed to landscape as a verb, where to landscape an area was to alter it to conform to some kind of ideal (Bender 2006).

Such treatments have led landscape to be regarded as an objective reality that can be rendered to empirical study – a world "out there", to be viewed through the frame of a painting or a window (Thomas 1993). This objectified view of landscape is attested to by such metaphors as "moral high ground", "unknown territory", and "difficult road". But even *if* landscape is a world "out there", it is a world represented and engaged with by people. As such it becomes subjective, and is immediately open to a plurality of interpretations and meanings (Tilley 1994). Any one place can be experienced differently by different people at the same time, and the same person can experience the same place differently at different times (Bender 2006).

Although experiences of landscape are subjective, this does not dictate that landscape itself is passive. Landscape has a materiality which enforces a two-way relationship between it and its inhabitants – actions that are "done not so much *to* the landscape as *with* the landscape, and what is done affects what can be done" (Bender 2002: S104, italics original). Landscape is not a theatre of battle in the war against environmental determinants, rather "it is *with* us not against us" (Ingold 1993: 154, italics original).

1.2.2 - Time and Landscape

As common as there are idioms in language that objectify landscape, there are those that define landscape in terms of time. A "limestone White Peak" connotes the passing of millions of years of geological time, an "agricultural landscape" describes the effects of a few centuries of historically specific time, and a "ritual" or "phenomenological landscape" denotes time passed from the perspective of an individual's experience (Bender 2002). Time is fundamental to the conception of landscape, and landscapes are never "finished", but rather change constantly with time - "*Landscape is time materialising*" (Bender 2002: S103).

The fact that the configuration of landscape is not just a spatial phenomenon, but a temporal one was first popularised by W.G. Hoskins (1955). Hoskins recognised the landscape as a palimpsest of previous human activity, structured by changing social, cultural and economic practices. His work in Britain was broadly contemporary with that of J.B. Jackson in the States, whose work focussed on the juxtaposition between the landscapes of "ordinary" people and the more formal structures imposed by state and federal government (Bender 2006). Both can be criticised for a lack of self-reflexivity, i.e. for their respective failures to account for their own socially and historically constituted perspectives on the landscape they studied (ibid). The importance of social, political and personal context to both object and subject of study was first recognised by Raymond Williams, whose Marxist perspective enabled him to equate phrases such as "a fine prospect" with both what can be seen, and what potentially can be owned and/or controlled (ibid).

Time is clearly important to archaeologists, indeed it "structures their subject" (Bevan 2004: 15). But conceptions of time cover different intervals, and different types of experience. The archaeologist's idea of time may cover several millennia in one word, implying one homogeneous epoch, such as

Neolithic. Time may be conceived of as chronology, i.e. the order in which events happen, or as history, i.e. specific events taking place at specific times (Ingold 1993). Time may also be close grained, referring to the passing of years, months, days or hours, and equally may be cyclical, in the case of passing seasons. As people move through the landscape following these temporal cycles, so the landscape is shaped by, and shapes their actions (Edmonds 1999a).

For many in the modern Western world, time maybe measured on a linear scale, as in "clock time". For some, clock time may be a concept that does not actually require the existence of clocks, but is rather an abstraction of cyclic astronomical time (Ingold 1993). For others, clock time is not just a measure of convention and convenience, but is a mechanism of social control (Bender 2002). Although clock time is measured on a linear scale, it is not necessarily experienced as such, at some times flying past, and at others, dragging interminably slowly.

Social time is another significant component that structures people's lives. Ingold has described the array of practical tasks with which people engage in their lives as the *taskscape*, and defined social time as that when the taskscapes two or more "mutually interlock", or put simply, when people conduct these tasks together (Ingold 1993, Edmonds 2006). Taskscapes are distributed across time and space, and so time and landscape are inexorably intertwined.

1.2.3 - Experiencing Landscape

A dominant theme in many accounts of archaeological landscapes over the last 15 years has been that of the embodied subjective experience, or the *phenomenological* approach. Phenomenology seeks to elucidate the nature of human existence and understanding of the world. Moreover, rather than just understanding human experience, the phenomenological approach asserts that nothing in this experience and understanding can be taken for granted (Tilley 1994). This is diametrically opposed to Cartesian empiricism and positivism, which takes the reliability of thoughts and observations as an unquestioned starting point for explanation (Thomas 2006).

Phenomenological thought has its origins in the work of Franz Brentano, and was developed further by Edmund Husserl, Martin Heidegger, Maurice Merleau-Ponty and Emmanuel Levinas (ibid). Heidegger rejected the Cartesian distinction between mind and body, and also the fixed relationship between object and subject. He believed that the way objects in the world were understood (or *disclosed*) was contingent on the attitude of the observer, and this calls into question the whole concept of an objective reality. Merleau-Ponty focussed on the nature of perception itself. Fundamental to his view of perception is the concept of embodiment, as it is through the senses and the movement of the body that perception is experienced, and that perception cannot be experienced by a disembodied mind. For Levinas, the responsibility of ethics were of supreme importance, as human existence in the absence of others was meaningless, and so it is to these others that humans should be compelled to act ethically, so as to reduce their suffering (ibid).

The phenomenological approach has pervaded many disciplines, including archaeology. Rather than seeing monuments and/or landscapes as simple geometrical forms or regions of *space*, phenomenology emphasises their sense of *place* in which people have meaningful experiences. Spaces become meaningful places as a result of human action, and the presence or absence of others. For Tuan, the human body has a central role in this, and provides an important structuring principle on the way architecture is created – for example many rooms have a door that broadly mirrors the proportions of the human body, even if this maybe accentuated in size. Tuan also argued that buildings and monuments act as foci of meaning, and through architecture, people's experience of place can be transformed (Tuan 1974, 1977 in Thomas 2006).

Perhaps the most often cited and influential use of the phenomenological paradigm within archaeology and landscape studies has been Chris Tilley's *A*

Phenomenology of Landscape (1994, Brück 2005, Fleming 1999, 2005, Thomas 2006). In this study, Tilley combined principles of phenomenology with ethnographic studies from a number of non-Western traditional societies, and applied these to a series of encounters with Neolithic monuments in Wales, and along the Dorset cursus. Using phenomenological approaches, Tilley sought to explore the landscape settings of prehistoric monuments in terms of meaningful places, or locales. In his review of ethnographic evidence, he demonstrated how such locales could provide a visual reference to the presence of the ancestors or other metaphysical entities, represented by features in the landscape. These locales provide important senses of identity, and links between the present and the past, as well as links between the worlds of the living and the ancestors or other supernatural agents.

Tilley (1994) used this evidence to create an analogy as to how Mesolithic and Neolithic peoples could have experienced landscapes and monuments in the past. As an analogy, it serves to provide a way of thinking about landscapes and monuments, rather than offering a direct parallel or explanation. This premise forms the basis of Tilley's own analysis of monuments in three study areas: two in Wales, and a third along the Dorset cursus. In phenomenological terms, his case studies were centred around his own embodied experiences of encountering monuments in the field, and revealed nuanced interpretations that could not be recognised by simply "looking at the two-dimensional plane of the modern topographic map" (ibid: 75).

Phenomenological approaches in archaeology are not just confined to movement through the landscape, and the ways that monuments may reference gross topographic features, structured by what Tilley called the "bones of the land" (ibid: 74). Equally importantly to this thesis, the experiential effects of the articulation of space within monuments has also received increasing attention over the last 10 or so years, with notable examples focussing on Avebury, Stonehenge, Woodhenge and Durrington Walls (Barrett 1994, Pollard 1995, Thomas 1993). It should be noted that many such studies are largely confined to considerations of visual experiential phenomena, and that in reality, experiences of place would involve not just seeing, but hearing, smelling, tasting and touching. In addition, embodied movement implicates the active seeking of sensory information from the environment, as well as physical feedback from the activity of movement – the "muscular consciousness" of Bachelard (Gibson 1979, Bachelard 1964 in Ingold 1993: 167).

Although playing an important role within Landscape Archaeology, phenomenology is not without its problems. Extensively discussed elsewhere (Brück 2005), a few key criticisms are mentioned here. One main problem with these approaches is how the modern experience of landscapes or monuments might equate to those of people in the past. Relationships between monuments and landscapes that seem significant today may not have been important in prehistory, and if they were, they may not be the only factor influencing monuments' locations. This problem is not just that the significance of landscapes and monuments is culturally constituted, but also that the embodied experience itself is not universal, and depends on variable attributes such as age, gender and fitness (ibid). Phenomenological accounts often concentrate on the experiences at ceremonial monuments, and focus less on the broader experiences of day-to-day life, such as subsistence, and the broader senses of scale over which these would operate (Edmonds 1999a, Hind 2000, Pollard 1999). This latter activity receives all but the most scant attention in Tilley's *Phenomenology* (Hind 2000, c.f. Tilley 1994). Equally, phenomenological accounts describe the experience of *being* at monuments, but often ignore the importance of actually *building* monuments with other people, and how this process would in turn would be a mechanism for forging social relations (Edmonds 1999a). Phenomenological accounts are often of a solitary nature, which seemingly ignore the fact that the monuments that are often under consideration would have witnessed ceremonial activities attended by many (Brück 2005). A final problem with phenomenological accounts is that the means to portray the observations and arguments presented, often do them little justice, and leave little opportunity for reinterpretation short of visiting the locations for themselves (Brück 2005, Cummings 2000, 2002, Cummings et al 2002). This final problem has recently received specific attention from Fleming (2005).

As suggested above, people's experience of the world, and thus landscape, is not *just* shaped by encounters with phenomena in the landscape, but rather meaning is socially constituted. The accumulated social experiences that a person gains in the world amounts to what Bourdieu has termed their *habitus*, and simultaneously, their experienced at any given time is shaped by their conditioned habitus. These are not so much habits, but more akin to a schema of unwritten dispositions, determined by repeated practice within social structures (Bender 2006). Giddens's Structuration Theory concerns itself more directly with how people (or agents), armed with their socially constituted habitus, help to shape the social structures around them by virtue of their actions, through a process of *agency* (ibid). All these actions and experiences are patterned both temporally and spatially throughout the environment in which people dwell (Ingold 1993).

1.2.4 - Defining and Representing Landscapes

If landscape is not land, nature or environment, what then is it? It is, from Ingold again, "In short, the landscape is the world as it is known to those who dwell therein, who inhabit its places and journey along the paths connecting them" (1993: 156). Such a broad term as it is provides a definition of landscape that is very inclusive, and whose study invites participation and collaboration from practitioners of many subjects. As Barbara Bender has said, "Landscapes refuse to be disciplined", and that they "make a mockery of the oppositions that we create between time (history) and space (geography) or between nature (science) and culture (anthropology)" (2002: S106, 2006: 304).

Just as the concept of landscape encompasses many different subjective experiences, so it also encompasses activities conducted at a variety of spatial scales (Bender 1993, Edmonds 1999a). These can be spatial scales of engagement performed by the people under consideration, ranging from the localised activity in and around a settlement, to the broader patterns of mobility taking place as part of the seasonal round. Equally, they can be scales of archaeological resolution, ranging from excavation of a locale defined as a *site*, to the patterning of artefactual residues or monuments across a whole region.

As a concept that is so inclusive, subjective, and combines a multiplicity of both spatial and temporal scales, landscape is difficult to represent. More specifically, is impossible to adequately represent using any one means. Returning to where this discussion began, historically the Western concept of landscape started as a means of representation (Daniels and Cosgrove 1988). Landscape painting is demonstrably subjective, and abounds with historically constituted symbolism and ideologies (ibid). It is an ostensibly more objective form of landscape representation that will be considered next – that of the map.

The assumed precision of contemporary maps belies any possibility that they maybe anything other than purely objective descriptions of the world. Yet this assumption is often made without any consideration of the possibility that "maps are a way of conceiving, articulating, and structuring the human world which is biased towards, promoted by, and exerts influence upon particular sets of social relations" (Harley 1988: 278). Whilst maps may superficially look like aids to exploration and navigation, they have also been implicated as tools of colonial exploitation (Bender 2006, Harley 1988). By providing an objectified view of the world, they can eradicate any locally indigenous and contingent organisation of space. Maps can be used to distort the truth, and become a source of power. This is not just confined to the colonial past, but is equally true in modern Western maps, which may omit certain (often military) features (Bender 2006).

Modern maps also reinforce a particular way of viewing the world, and this becomes evident when comparing them with landscape representations from other cultures. An example that illustrates this well are the "maps" painted by the Yolngu Australian Aborigines. Australian Aborigines believe that their landscapes were created in the Dreamtime, by ancestral beings. Human beings were nurtured by the ancestors, but simultaneously, are also responsible for protecting the ancestors in the landscape. The Yolngu maps are multifaceted in their meanings. On one level they function as topographic maps, which enable the people to locate themselves, and important resources in the landscape. On a spiritual dimension, the maps tell of creation myths and the ancestors, and help the clan affirm their ancestral claims over land. The maps' symbolism also represents a form of sacred knowledge, into which one must be initiated through ritual. Bender has described this combination of topographic and ancestral mapping as "turning temporal accounts into spatial grids" (2006: 309). These maps are also capable of being adjusted, so that "the ancestral past is subject to the political map of the present" (Morphy 1995). Such spiritual mapping is not just confined to painting, but can also be seen in the ways such cultures give significance to prominent features in the landscape, as at Ayers Rock (Tilley 1994).

The problems associated with representing landscapes and monuments go further than challenging the "Western Gaze". They also present real problems for how monuments and landscapes can be represented from the phenomenological perspective outlined above. Descriptions of landscape phenomena are often mainly textual, and the constraints of traditional publishing usually dictate that the number of illustrations that can be used to enhance phenomenological accounts are limited (Cummings 2000a, Sanders 2000).

Further problems exist with representing landscapes and monuments using the conventions of maps or archaeological plans. Maps and plans present information in a very particular way. Although arguably useful pragmatic conventions, these means of representation display the world from a detached, abstracted and disembodied perspective. This unnatural ability to see everywhere from no one particular point has been described as a "God-trick" (Haraway 1988, 1991 in Gillings 2002). Although maps and archaeological plans may represent Cartesian space perfectly faithfully, they do little to convey how landscapes and monuments as places serve to structure experience in an embodied way.

As with the concept of visualism, discussed in 1.2.1 above, the problems associated with the map perspective as a way of viewing the world have important ramifications throughout this study. The limitations of the map perspective have important implications for the use of GIS in archaeology, particularly for the interpretation of the results of viewshed analysis, discussed in Chapters 3 and 4. The limitations of this form of representation also provide the main rationale behind the use of VR, and so are discussed again in Chapter 5.

1.3 - New Technologies

Developments that have occurred in the new technologies of GIS and VR, along with multimedia, should in principle offer Landscape Archaeology affordances that are consistent with some of the aims discussed above. In particular these are issues of resolving different spatial scales of activity and analysis, and looking at new ways of representing landscapes and monuments.

GIS technologies allow integration of different forms of evidence within one analytical environment. This enables topographic, environmental, and archaeological data to be readily combined and displayed via a map based interface (Lock 2003). One area of key importance to Landscape Archaeology is that given some basic provisos, this data can be very rapidly negotiated at different levels of spatial scale. In practical terms this means that data captured at quite high spatial resolution, such as lithics recovered from field walking survey, can be displayed within a much broader landscape context. This would enable many such surveys to be viewed together in their regional context, whilst still allowing the user to rapidly zoom in on any one survey to see its results in full detail. GIS also provide analytical tools that provide some index of landscape perception at or from given points (e.g. monuments), using procedures such as viewshed analysis (e.g. Gaffney et al

1995, 1996, Wheatley 1995). Because the GIS allows integration of different forms of information, field walking data could be interrogated from the perspective of visibility between monuments, so addressing questions such as "which lithic scatters are visible from which monument" becomes possible. This offers the potential to investigate archaeological data from spatial scales that range from "site" or "locale", to "region" relatively quickly and easily.

VR technologies have the potential to enable archaeologists to address issues of representing landscapes and monuments, and this is important for three reasons. Firstly, they enable a different kind of view from that of the map perspective. In principle, this can be an embodied first person perspective, and can allow movement freely throughout the landscape or monument under consideration (Chan 2001). Secondly, in being able to portray landscape and/or monuments, VR techniques provide another means of negotiating different spatial scales. Thirdly, where landscapes or monuments have been significantly altered or destroyed since antiquity, these techniques may allow reconstruction and exploration in ways not possible by other means (Barcelo 2000). For those under immediate threat they also offer the potential of digital conservation (Anderson 2003).

A third technology to develop in parallel with the other two is that of interactive multimedia. Interactive multimedia allows the combination of a variety of digital media types (e.g. static images, text, video clips and VR models) to be integrated into a single interactive environment. Developments in Internet technologies in the last 10 years now enable interactive multimedia to be very effectively delivered via the Web, where previously this would have been achieved via CD-ROMs or local area networks. The affordances offered by interactive multimedia have implications across many disciplines in addition to archaeology. Importantly to this study, they enable archaeologists to disseminate their research findings in new ways (Exon et al 2000). Not only do web sites provide liberation from many of the constraints of traditional publishing in terms of the number of images that can be published, and the way that information can be structured, but also they offer the possibility of engaging with the kinds of VR representations described above (Cummings

2000a, Hodder 1999, Holtorf 1999, Sanders 2000). The latter is crucial if VR is to be used for anything more engaging than simply providing impressive reconstruction images or animated sequences for television programmes.

One key area for the application of interactive multimedia technologies is in the growing field of e-Learning. E-Learning can be defined as a contraction of *technology enhanced learning*, where the use of communications and information technologies enable a pedagogical and/or pragmatic enhancement to the educational experience received by students. The widespread investment by many institutions in technologies such as Virtual Learning Environments suggests that E-Learning is playing an increasingly important role within the broader context of learning and teaching within British Higher Education and so is of additional importance to archaeologists working in this context. Current uses of Learning Technologies (i.e. the technologies, including multimedia, that facilitate e-Learning) emphasise the constructivist approach to learning (Alessi and Trollip 2000, Mayes and de Freitas 2004). In this approach, students are actively engaged in creating their own knowledge, rather than having it instilled in them by a lecturer. This is also the context within which this study has been undertaken.

The three broad areas of technology described above would in principle seem to offer great value to studies in Landscape Archaeology. Yet this potential still appears to remain somewhat under-utilised (Goodrick and Earl 2004). It is true that each of the technologies suffers from significant theoretical and methodological problems, and that some of these are probably irresolvable in the short or medium term (Tschan et al 2000, Wheatley and Gillings 2000). As these technologies provide the main focus of the study, they are discussed in more detail in the following chapters. Although each have specific problems of their own, one problem they all share is that none of them are theoretically neutral, and as a result, the uncritical use of either is problematic (c.f. Aldenderfer 1996). Whilst this is possible to say with hindsight, it is a common criticism of early uses of these technologies in archaeology, particularly in the cases of GIS and VR. It is also partly true with the use of multimedia in e-Learning, although this whole field has undergone more recent paradigm shifts than archaeology, and so the situation is slightly more blurred.

The lack of uptake may be due more to the perception that each of these techniques remains too specialised for those scholars who consider themselves more as generalists (Gidlow 2000). More specifically, as in the case of VR, there is a perception that these techniques are too difficult, too expensive, and have little interpretative value (Goodrick and Earl 2004). This situation maybe perpetuated in the way such studies are published. For many years, the results of these studies have been published in quite specialised circles, typically through dedicated edited volumes (e.g. Allen et al 1990, Aldenderfer and Maschner 1996, Lock and Stancic 1995, Westcott and Brandon 2000), and proceedings from Computer Applications in Archaeology (CAA) meetings, with relatively little work reaching more mainstream journal publication (e.g. Llobera 1996). Only relatively recently have more accessible volumes been published, such as that by David Wheatley and Mark Gillings (2002), or by Gary Lock (2003).

1.4 – Aims of This Study

As noted in the discussion above, whilst the uptake of new technologies by Landscape Archaeologists has so far been slow, it has not been entirely absent. Important theoretically driven critiques and examples of the use of GIS and VR have been forthcoming during the last 10 to 15 years. In its broadest sense, the overall aim of this thesis is to further embed some of the theoretical implications for both GIS and VR in archaeology, and seeks to apply both in an integrated study of one region, in one period. Importantly, the study seeks to apply *both* these technologies within the context of a fairly well researched area, with relevant and valid theoretical questions. This context is provided by the Neolithic period of the Peak District, and focuses specifically on the ceremonial monuments located in the area known as the White Peak, which lies at the geographical heart of this area.

Although critically aware uses of either technology have been demonstrated in many cases elsewhere, these applications have largely been used in isolation to each other. Only rarely have authors considered their uses together (Exon et al 2000, Pollard and Gillings 1998, Roughley 2004, Roughley and Shell 2004, Trick 2004). In addition, there appear to be few studies where both GIS and/or VR have been integrated using interactive multimedia for educational purposes within archaeology (Nixon and Price 2004). The potential synergies between these areas have been recognised for some time (Reilly 1991, Wheatley et al 2002), and these have been exploited in geography (Fisher and Unwin 2002).

This broad aim can be distilled into three specific areas of inquiry:

The first of these is to investigate how the use of GIS and VR techniques can be used in complementary ways to resolve human experience at different spatial scales. At the broader regional scale, this will be investigated using GIS based viewshed analysis. A critical review of the methodology, existing case studies, and relevant theoretical concerns, along with the analysis and subsequent results and interpretations are provided in Chapters 3 and 4 of this study.

The second aim of the study is to investigate if and how these two broad technologies can be integrated together. This considers their combined use either as research techniques, or as means of disseminating research findings. The results of the GIS analysis presented in Chapter 4 will be used as a vehicle for this potential integration, which itself is considered in Chapters 6,7, and in the conclusion, Chapter 8. A more intimate and close-grained scale of engagement with specific monuments is explored via the use of VR techniques. These are critically reviewed in Chapter 5, with case studies presented in Chapter 6 and 7.

The third and final main aim of the study is to demonstrate how technologies deployed in research can, in the context of current pedagogical thinking and the affordances of rapidly evolving learning technologies, be used equally in the context of learning and teaching. These are foregrounded in the general principles of constructivism, and more specifically with variants such as Inquiry Based Learning (Mayes and de Freitas 2004, O' Rourke and Kahn 2005, Tam 2000). This is specifically discussed in Chapter 7.

Although not a research aim *per se*, the study aims to be guided by the broad principle of theoretically grounded practice. This means that the work is mainly practical, but guided by appropriate theory. As such the work is not a theoretical one – although relevant theory will be discussed in the context of the three main case studies. This will mainly be done so as to set context, rather than to specifically develop new theoretical insights. Equally, whilst the work is practically based, it is not an in depth technical study either – most if not all the techniques used here have been extensively documented elsewhere. Instead this study focuses on the implications of their use within wider archaeological practice, both in research and learning and teaching
In order for these technologies to be able to demonstrate or do justice to their affordances, their use needs to be situated within a well understood archaeological context, with a well established series of models to explain it, and have valid questions regarding the different spatial scales that can be resolved by the technologies. It is this archaeological context that is presented in the next chapter, and it is this that forms the foundation for the work presented in the rest of the thesis.

Chapter 2 – Introduction to Study Area and Past Archaeological Research

The overall aim of this chapter is to provide the archaeological context in which the case studies presented in Chapters 4, 6 and 7 are situated. Arguably the most common generic criticism of the use of GIS and VR in archaeology is a failure to locate such studies within appropriate and relevant archaeological models, and so this is an essential prerequisite to those presented throughout the rest of this thesis.

The chapter provides a general introduction to the study area, the Peak District National Park, and a historiography of the archaeological work through which its prehistory is understood. First, it describes the underlying geology, as well as its past and present land-use in order to define five landscape-scale units of analysis and assess archaeological visibility within each. Then, the datasets, interpretations and theoretical frameworks which are pertinent to the Early and Later Neolithic of the study area are discussed, from antiquarian times to that of current scholars.

2.1 Introduction to the Peak District

The Peak District National Park sits at the southern extent of the Pennines, and occupies much of northern Derbyshire, parts of north Staffordshire, Cheshire, South Yorkshire and West Yorkshire (Figure 2.1). This section provides a general introduction to external factors affecting archaeological data collection and interpretation: Section 2.1.1 outlines the underlying geology of the area; Section 2.1.2 reviews past and current land use and the effect it may have had on archaeological visibility. The former represents Tilley's "bones of the land" (1994: 74), the basis for the Digital Terrain Models used in Chapter 4; the latter, helps us understand the some of the biases inherent in the datasets which populate these models.

2.1.1 Geology

The Peak District can be considered geologically distinct from the Cheshire Plain to the west, the Pennines to the North, the coalfields and Magnesian Limestone to the East, and the Trent Valley basin to the South. Whilst this area, some 50 kilometres square, encapsulates landscapes which are diverse in character, it can be geologically divided into two broad categories, the White Peak and the Dark Peak. The White Peak sits at the centre of the Peak District, and is comprised of a broadly dome shaped plateau of Carboniferous limestone (Neves and Downie 1967, Wolverson-Cope 1998). This plateau is characterised by gently rolling hills, cut by deep and sometimes precipitous dales and dry valleys. It runs about 30 kilometres from Castleton to the north to just below Ashbourne in the south, ranging in elevations from 150 m to about 400 m at its highest at Eldon Hill, Castleton.

The White Peak is bordered on the West, North and East by the Dark Peak, comprised largely of gritstone uplands. They reach their highest to the North: over 600 m on the massive Bleaklow and Kinder Scout plateaux. The dramatic edges of the Eastern Moors, run North-South along the eastern side of the Derwent Valley, which are so popular with walkers and climbers today. To the west and south of Buxton, gritstones form the basis of the Staffordshire Moorlands. At the interfaces between the limestone of the White Peak and the surrounding gritstones run a number of shale valleys, and it is through these that the region's main rivers run (ibid). These are the Derwent, Wye, Goyt, Manifold and Dove. Much of the Dark Peak is covered by heather moorland or peat deposits today and, less amenable to extensive agricultural use, easily gives the impression of being "marginal land". This has encouraged a number of biases in prehistorians' interpretations (Kitchen 2000), which will be addressed later in this chapter. The underlying geology of the region is shown in Figure 2.2.

2.1.2 Past and current land-use and Archaeological Visibility

This chapter recognises five landscape-level units of analysis, defined by John Barnatt (1996a) as a basis for understanding prehistoric inhabitation of the Peak District (2.3.3 below). This section describes those divisions, and the effect past and current land-use has on their archaeological visibility.

2.1.2.1 The Higher Limestone Plateau (White Peak)

Fertile soils have led to this zone becoming heavily settled and farmed throughout historic times. The removal of earlier field boundaries, especially following the Parliamentary Enclosure Awards of the Eighteenth and Nineteenth centuries have eradicated any evidence for prehistoric field systems. While most of the area is devoted to grazing today, cereal cultivation dominated between the 12^{th} and 18^{th} Centuries, ensuring the destruction of many subsoil features by ploughing. Two categories of evidence do remain – upstanding monuments and surface scatters.

Importantly to this study, this zone contains all the upstanding field monuments of the Early and Late Neolithic of the Peak District. In the earlier part of the Neolithic, field monuments are comprised entirely of burial mounds. There are 13 certain examples, with nearly double this number if we include possible sites that are either presently too greatly denuded to determine, or exist solely in the records of antiquarian investigators (Barnatt and Collis 1996, Barnatt 1996a). Approximately half of these existed as relatively small closed chambered tombs, providing no subsequent access to any remains after burial. The other half existed as long barrows, several of which had chambers made accessible via passages from outside the mounds. Many of these Neolithic tombs contained multiple inhumations, as has been characteristic of these monuments across much of Britain. Unfortunately all of these monuments have suffered either robbing, or excavation by antiquarians, and only a small number have since been investigated under contemporary field techniques (Manby 1965, Radley and Plant 1971, Marsden 1982).

During the later Neolithic, as in other parts of Britain, several of these earlier burial mounds became embellished in size, and in the process, any prior access to the chambers and burials within became curtailed. These have been termed the "Great Barrows" (Manby 1958, Barnatt 1996a), and include

Minninglow, Tideslow, Pea Low, Stoney Low, Ringham Low, and Bole Hill. Long Low, in addition to these, is a spectacular bank barrow towards the south of the plateau, and again this highly atypical form appears to comprise an earlier circular chamber, with later elongation of the mound to a length of over 100 metres. Also during the later Neolithic, radical new developments in monumental architecture are demonstrated by the Bull Ring and Arbor Low henges. These are similar in design principle to other henge monuments in Britain during the Later Neolithic. The role of these monuments in current archaeological models of the region is discussed further in section 2.7.3 below. The location of all the monuments discussed in this study is shown on Figure 2.3.

Agricultural improvements in this part of the Peak have yielded scatters of surface material that have been variously collected and studied from Antiquarian times to the current day (Garton 1991, Hind 2000, Marsden 1999). Although this data is beyond the scope of this study per se, they play an important role in our overall understanding of the region, and will also be considered below, in section 2.2.3.

2.1.2.2 The Shale Valleys and Lower Limestone Shelves

These valleys and lower lying shelves generally follow the courses of the main rivers in the Peak District - the Derwent, Dove, Wye, Manifold and Goyt, and these are also shown on Figure 2.1. Along with the limestone plateau of the White Peak, these zones represent the other prime foci for historic settlement, agriculture, and latterly industry in the Peak. Whilst again these processes will have themselves caused the removal of evidence, archaeologists face another problem when assessing these areas. By the very nature of being valley sides and bottoms, these areas have undergone millennia of extensive sediment deposition. This is both colluvial, i.e. that which washes down the valley sides to the bottom under the effect of gravity, and alluvial, i.e. that which is deposited by the rivers flowing through them. The net result is that many metres of heavy shale, clay, and brown soil deposits separate us from the potential evidence below, and it is impractical to excavate these areas under purely research conditions. So whilst the state of preservation of these remains is probably very good, they largely remain archaeologically invisible (Barnatt 1996a).

2.1.2.3 The Eastern and South-Western Gritstone Uplands

At some point around 1000 BC, the then fertile soils of the Eastern Moors started to deteriorate, resulting in the formation of what has often been described as the bleak and barren moorland seen today. This soil deterioration was precipitated by increased rainfall under a worsening climate, but was also exacerbated by intensification of prehistoric agriculture, and the continued removal of the natural tree cover throughout later prehistory (Bevan 2004). Used mainly for rough upland grazing in historic times, the Eastern Moors have undergone significantly less agricultural improvement than the limestone plateau. Although several large areas have been cleared for improvement to create estate farms, such as at Chatsworth, so these estates have also conserved large areas of the Eastern Moors for grouse shooting. As a result, there has been excellent survival of upstanding prehistoric monuments in this area, sufficient for Barnatt to comment that "Something like half the total area probably once covered by prehistoric fields and settlements and fields to the western side of the East Moors retains prehistoric remains". (Barnatt 2000: 10). Whilst this preservation is good, easy recognition of these monuments is not always easy on the heather coated moorlands, and they are often found "with the feet rather than the eye" (Barnatt and Smith, 1997: 24).

Although the absence of intensive ploughing on these gritstone uplands has resulted in a corresponding lack of surface material, occasional finds do occur, and events such as moorland fires create suitable conditions for more systematic surface survey (e.g. Radley 1966). Evidence for Early Neolithic activity on the Eastern Moors comes from lithic artefacts, with over 10 of the 80 or so Earlier Neolithic polished axes found in the Peak recovered from the Eastern Moors (Barnatt 1996a). It has also been suggested that lithic artefacts from excavations at Swine Sty on Big Moor have Later Neolithic origins, although this unique settlement itself is interpreted as being Bronze Age in date (Garton and Beswick in prep). Upstanding field evidence from the Early Neolithic is very poor in these areas compared to that in the White Peak, with the vast majority being Bronze Age. It is likely that any evidence for Neolithic field systems has been eradicated by their Bronze Age successors (Barnatt, 1996a)

2.1.2.4 The High Northern and Western Gritstone Uplands (Northern Massif)

The vast upland tracts of this zone, North of the Derwent Valley, saw the onset of blanket peat formation during the Mesolithic, although this was initially sporadic, and did not reach its current extent until the end of the Neolithic or later (Tallis and Switsur 1983). Because of its extensive blanket peat coverage, this upland zone has never been attractive to farming in historic times, apart from for rough upland grazing. Archaeological visibility in this area is correspondingly low, with the exception of a few Bronze Age barrows and surface finds (Barnatt 1996a, 2000)

2.1.2.5 The Western Moors

Much of this area, lying on the limestone and shale boundaries, has been extensively farmed in historic times. As with other areas that have suffered the effects of improvement in the Peak, some evidence does still remain. Although there are no upstanding Neolithic monuments in this area, there are a numbers of Bronze Age barrows in the Goyt, Dove and Manifold Valleys, as well as on the lower gritstone shelves. There is also fragmentary evidence for prehistoric agriculture from Coombes Edge, and to the South West, Gun Moor. As with the White Peak, and main river valleys discussed above, the presence of these features at all suggests that there could have been many others prior to historic land improvement (Barnatt 1996a, 2000).

2.1.3 Summary

To an extent the delineation of these five zones is a historical and arbitrary one, which may have had little significance in prehistory. Taken together however, these different zones would have provided diverse but complementary affordances for a range of subsistence activities in prehistory. Importantly for this study, despite the recognition of biases in archaeological visibility across the region, virtually all the upstanding field evidence from the Neolithic is confined to the White Peak, and so it is this zone that will receive the majority of attention in this study.

2.2 Previous archaeological research in the Peak District

This section presents a history and critique of archaeological research in the region over the last three centuries.

2.2.1 Antiquarians

Archaeological remains from the Peak were first documented, in any meaningful way, in the 1780's by Sammuel Pegge (1785) and Hayman Rooke (1782). By far the greatest number of Antiquarian excavations were performed by Thomas Bateman and his associates (including his dog, Nutt) during the first half of the nineteenth century (Hodges 1991). Seemingly motivated by the good intentions that we now term "rescue" and "conservation", Bateman's fieldwork technique was better than many of his contemporaries, although still alarming compared to those of today (Marsden 1999).

Although Bateman documented burials and artefacts well, his attention to structural features, soil types, and stratigraphy is inconsistent. Being primarily interested in human evolution, he focussed his attentions on the centre of barrows, where he thought he was most likely to find human remains and associated artefacts (ibid). As the state of preservation of un-cremated bone is very poor on the acidic soils of the gritstone, he devoted the majority of his efforts to the barrows of the White Peak. Apart from the sheer number of barrows he excavated (over 400 between him and his colleagues), Bateman's work still remains of great importance to us today, because for many monuments, his records constitute their only surviving traces (Bateman 1848, 1861)

After Bateman's death, the next large-scale systematic excavation was the Heathcote family's analysis of the extensive Bronze Age remains on Stanton Moor in the 1920's. Although excavation techniques had advanced significantly in the intervening years, Heathcote's chief concern was the recovery of bones and artefacts which would contribute to a relative chronology, and he too confined most of his efforts to the excavation of burial features (Heathcote 1930)

2.2.2 Culture history

In the Peak District, all the research to the mid-20th Century adopted the "site" as the fundamental unit of archaeological analysis. At no point had any scholars attempted to make broader sense of what was by now a not inconsiderable body of primary data. This changed in the mid 1950's when two independent attempts were made to consolidate, integrate and interpret the available excavation data from the region (Fowler 1955, Armstrong 1956). Both based their models almost exclusively around the corpus made available by Bateman in his two volumes. Although the authors differed in their scope (Armstrong considered the periods from the Palaeolithic through to the Bronze Age, with Fowler specifically describing the Neolithic and Bronze Ages), they were both proponents of the culture history paradigm: in both accounts the sequential transition in mortuary practices and artefacts were ascribed to successive migrations of people into the area.

Whilst both these works are obviously dated both in methodological and interpretative terms, they did represent the first real attempts to "move beyond the monuments", and tell a story rather than just provide ordered lists. Culture historians, like Childe, Fowler and Armstrong, at least stepped beyond the data to ask "why", rather than simply listing "what" and "when" (Johnson 1999).

2.2.3 Surface Collection, Field Survey, and Excavations between the 1950s and 1980 in Britain's first National Park

In 1951, The Peak District became Britain's first National Park, designated by the "National Parks and Access to the Countryside Act" of 1949. Although not providing any additional protection to un-scheduled monuments per se, changes in local planning policy and improved access to the land created conditions for more extensive surface collection of artefacts. Agricultural improvement and historically established quarrying rites were exempted from these enhanced planning regulations.

The collection of "surface material" had been going on in the Peak for as long as Antiquarians had been opening barrows. Bateman was known to buy worked flints found by others and he, at least, documented and deposited them with Sheffield City Museum (Garton 1991). Many other such finds disappeared into private collections. Where original artefacts are available for re-analysis, methodological biases in their collection rendered their study "not as useful as one might have hoped" (ibid: 3).

The standard of surface collection began to improve after the 1950s, with some notable keen amateurs making efforts to recover material in a non-prejudicial, systematic, and well provenanced manner. Amongst these were Alistair Henderson, Leslie Cooper, and most notably, Jeffrey Radley. Unlike many predecessors, Radley studied material from both the Eastern Moors (when possible) as well as the White Peak (Hart 1981, Hind 2000). He was non-prejudicial about the type of material he collected, and provenanced his finds to six-figure accuracy. His attention to Mesolithic material demonstrated that many larger scatters were palimpsests representing intermittent activity over thousands of years. These assemblages suggest a continuity of a sense of "place" from the Mesolithic through to the Bronze Age (ibid). Radley's most notable work was the systematic fieldwalking survey he undertook at Elton Common, with Leslie Cooper (Radley and Cooper 1968), and this was one of the first attempts to examine a Neolithic "settlement" via this method (Garton 1991).

Further systematic surface collection continued in the 1970s, with Clive Hart co-ordinating The North Derbyshire Archaeological Survey (Hart 1981). The survey, prompted by the threat of deep ploughing to facilitate growth of new "upland hardy" cereal cultivars, consolidated existing Sites and Monuments Records, Aerial Photographs, and new fieldwork (ibid). Hart categorised the available data both by chronology, and landscape zone. Importantly he identified a number of Neolithic assemblages from the Eastern Moors (ibid: 37)

2.2.4 - Field Survey

In the years after the Second World War, a recognition of the importance of archaeological landscapes was crystallised by the Council for British Archaeology's *A Survey and Policy of Field Research in the Archaeology of Great Britain* (1948). This document created a clear mandate for the accurate assessment and survey of upland archaeological features. Locally, this was implemented by the Hunter Archaeological Society's "Scheme for Archaeological Research" in 1949, resulting in a pre-cursor to the modern day Sites and Monuments Record.

In the Peak District, similar work was being undertaken by Leslie Butcher, a former mining engineer, whose training had clearly equipped him with the necessary skills to produce detailed and accurate maps. Butcher was the first to document many sites on both the gritstone moors and the limestone White Peak, surveying upstanding features from prehistory through to the Medieval period (Barnatt and Smith 1991, Beswick and Merrils 1983).

From the beginning of the 1960s, a number of excavations and surveys were conducted on the Eastern Moors in response to perceived environmental threats (Lewis 1966, Barnatt and Smith 1991). A key feature of this work was that for the first time, equal attention was paid to settlement and agricultural features as to those categorised as "ceremonial". This work started to see a shift away from "sites" as isolated entities, and started to consider the relationships between features over the broader landscape, be they sacred or profane (Heath 2004).

2.2.5 New Archaeology

Most archaeological work in the Peak District undertaken between 1950 and 1980 was interpreted in a culture historical framework: rare comparisons between sites were still on a typological basis, with the differences between them often accounted for by migrations of people (e.g. Manby 1958). The New Archaeology of the 1960s and 1970s started to demand *explanations* of the past rather than just *descriptions*. Often borrowing ideas and techniques from the natural and physical sciences, New Archaeology sought to explain human history in terms of systems and processes. Amongst these were economic systems, which were seen largely as responses to environmental determinants. In the Peak District, the first syntheses characteristic of the New Archaeology were those of Hawke-Smith (1979), and Bradley and Hart (1983).

2.2.5.1 - Hawke-Smith

Hawke-Smith's thesis aimed to undertake an integrated economic, environmental and artefactual analysis of the regions between Kinder Scout and the Trent Gravels, from north to south, and from the River Dove to the River Derwent, from west to east (1979). He believed that there was a direct relationship between densities of past populations and their ability to produce enough food to support them; when economic systems could no longer cope, migration inevitably occurred. He believed that Neolithic societies practiced a mixed rather than pastoral economy, with cereal cultivation as the staple crop and a critical factor in limiting human population growth. However, crop production would itself be limited by a number of environmental conditions, the most important being soils. With these determinants in place, he hypothesised that prehistoric settlement would focus around core areas, suitable for crop cultivation. The margins around these core areas would be used for other complementary subsistence activities e.g. hunting or the collection of otherwise non-domesticated foodstuffs.

To test this hypothesis, Hawke-Smith produced a series of landscape zones, or "land facets", characterised by their suitability for various economic activities, ranging from hunting to grazing to arable cultivation. These land facets were largely based on modern soil maps produced by the Ministry for Food and Fisheries, although some soil horizons were also studied in the field. These land facets were then compared against the archaeological evidence available at the time. He then argued that the limestone White Peak was the first area to be colonised in the Neolithic, by farmers whose own "core" area started at the Trent Gravels. During the Neolithic, the White Peak became increasingly used for agriculture. The population dutifully increased during the rest of the Neolithic, until when in the Early Bronze Age, this part of the Peak had reached its "carrying capacity". As with earlier models, this precipitated expansion onto the supposedly marginal and agriculturally impoverished gritstone East Moors.

Hawke-Smith has been criticised for a number of grounds. Firstly, he took the distribution of Neolithic artefacts across the whole region at face value, and paid no attention to how historic processes have biased their recovery in different ways, in different parts of the Peak. He also ignored emerging evidence for Neolithic use of the Eastern Moors (Hart 1981, Barnatt 1996a, Hind 2000). Secondly, his "land facets" were largely derived from *contemporary* soil maps. As well as being very simplistic in the assumption that past soil conditions were the same as those at the present, the degree of spatial resolution of these is quite vague (Barnatt and Smith 1991, Barnatt 1996a). Where he did consider new field data, from four soil horizons across the whole Peak, his interpretation of these has been questioned (Barnatt and Smith 1991, Barnatt 1996a, Hind 2000, Fisher 1985). Finally, Hawke Smith presumed that fertile loessic deposits had eroded from the gritstone Eastern Moors by the Neolithic, accounting for their relative unsuitability for cultivation. Loess is confined to the White Peak today, but Piggott's discovery of loessic deposits near Abney, and on Big Moor, suggests that these soils could have been present on the Eastern Moors as well (Piggott 1962, Fisher 1985)

2.2.5.2 - Bradley and Hart

In Bradley and Hart's (1983) study, they chose to evaluate Hawke-Smith's models of the Peak based around his "land facets", by comparing them against the artefactual data presented in Hart's recent survey (1981). They were not interested in the details of his "ecological arguments" *per se*, but in using the new evidence to "provide a more extensive test of Hawke-Smith's projections than the author himself could do using the material available to him" (Bradley and Hart 1983: 179). They offered the following results:

For the Early Neolithic, Hawke-Smith's model of expansion into, and settlement of the limestone was left largely unchallenged, commenting that the vast majority of lithic artefacts for this period had been recovered from the limestone White Peak. These assemblages were dated by the presence of various projectile points. This being the case however, about one third of the material considered was found away from the expected arable facet, in the projected woodland zone. They suggested that this was either indicative of exploitation of woodland areas modified earlier, possibly in the Mesolithic, or of continued use of woodland areas for hunting.

Of significance to this thesis, they also examined the location of six Early Neolithic burial mounds. They noted that these had a stronger association with the grazing land than the arable zones, "suggesting they were built around the edge of the more favourable soils". As these monuments also tend to occur away from the main lithic scatters, they concluded that the location of these cannot be treated as the centres of different but contemporary prehistoric "territories".

In the Later Neolithic, they concurred that there was now a greater degree of correlation with artefacts and the arable facets, using this to refute Kinnes' suggestions that the Later Neolithic economy was largely pastoral (ibid). They also argue that the White Peak remains very much the focus of "settlement" at this time, based on the distribution of Late Neolithic pottery reported by Vine (Vine 1982, 105). Interestingly, they also noted the apparent concentration of Late Neolithic polished stone axes, along with Macehead Complex artefacts, around the vicinity of the Arbor Low Henge monuments. Both types of artefacts originate from outside the region, implying to them that occupants of this zone had better access to contacts from outside the Peak District.

Of significance to this thesis again was that the distribution of the Later Neolithic burial mounds, which now seem to favour the woodland facet, was also now better correlated with the artefactual distribution for this period. The rest of their study focussed on the Bronze Age and so is beyond the immediate scope of this study

Bradley and Hart's synthesis has been criticised on a number of grounds (Barnatt 1996a, Hind 2000, Edmonds and Seaborne 2001). Firstly, in their explicit attempts not "to examine the ecological arguments presented by Hawke-Smith" or indeed to "assess his reconstruction of the changing character of the soils" they inherited all of the criticisms levied at Hawke-Smith in the preceding section. Secondly, whilst they certainly had a far more extensive dataset to interrogate than Hawke-Smith, they again took it at face value, and failed to engage with the different biases affecting artefact recovery from the different parts of the region.

Both the above studies (Hawke-Smith 1979, Bradley and Hart 1983) can also be criticised for accepting the primacy of economics as the main driver behind human activity within past societies. Implicit in Hawke-Smith's arable based economy is the additional assumption that settlement and agriculture were sedentary and permanent during the Neolithic and Bronze Age. The key problem with this hypothesis is the still very scant evidence for crop cultivation and/or permanent settlement in the Neolithic of the Peak District, or the rest of Britain. As Bradley and Hart do not refute this hypothesis, they get to share this criticism by default. The argument also rings of a form of environmental determinism that is now largely discredited.

The work of Bradley and Hart remained the dominant synthesis of the region for nearly 15 years. During this time, important new fieldwork was undertaken, along with the publication of some significant reviews and corpuses summarising the existing state of archaeological evidence for the region (Barnatt and Smith 1991, Garton 1991, Barnatt 1990, Barnatt and Collis 1996). None of these however sought to reinterpret this considerable body of evidence within the broader paradigmatic and interpretative shifts that had characterised the emergence of the "Post Processual" archaeology, and its importance implications for our understanding of the Neolithic and Bronze Ages in Britain. The need for this reinterpretation was answered by John Barnatt, whose publication of "Moving Beyond the Monuments" in 1996 represented a landmark in studies of the Peak (Barnatt 1996a).

2.3 Moving Beyond the Monuments – Post-Processual and Landscape Archaeology in the Peak Since the 1980s

2.3.1 Understanding the Neolithic

In the previous 10 years before Barnatt's 1996 paper, the traditional view of a Neolithic Revolution, which entailed the adoption of sedentary agriculture in favour of mobile hunting and gathering, was being increasingly attacked for a number of reasons. Firstly, if Neolithic people lived in sedentary settlements, then these settlements were proving very hard to find, with the number of securely identified Neolithic domestic structures for the British Isles still being very small. Secondly, if arable farming was the norm, then the economic products of this, i.e. cereal remains, were proving equally elusive (although the conditions required for preservation and recovery of these are quite particular compared to those of animal bones). Bones of cattle on the other hand pre-dominate throughout a number of contexts, both ritual and "domestic". Thirdly, re-assessment of lithic artefacts assemblages described as Neolithic, often have a significant component bearing much resemblance to Mesolithic artefacts, suggesting a "roll-call" of activities that resemble their Mesolithic forbears as much as they do any radical new shift in subsistence practices, whether brought in by migrations or not. Finally, many Neolithic burial mounds, when excavated using modern techniques, appear to themselves be built over land surfaces that yield evidence of prior Mesolithic activity. This has been interpreted to suggest that these highly durable monuments were constructed to echo an already existent, but archaeologically ephemeral sense of "place" within the landscape. The above themes are now commonplace in recent accounts of the British Neolithic and have been articulated by several authors over the last 20 years or so (Barrett 1988, 1994, Bradley 1984, 1993, 1998, Edmonds 1999a, 1999b, Pollard 1999, Tilley 1994, Thomas 1988, 1991, 1996, 1999, Whittle 1996, 1997).

Taking these lines of evidence together, the current view of the Neolithic in Britain depicts a way of life that was far more mobile than sedentary, with subsistence based around the grazing of cattle, supplemented by small-scale cultivation, and procurement of wild resources. Neolithic animal husbandry would entail seasonal movement of cattle across the landscape, exploiting a diverse supply of grazing opportunities throughout the year. The shift from manipulating the environment to attract wild animals in a predictable way, to a managed transhumant migration along established hunting paths is perhaps more one of perspective than change in overall life style. As such, this *gradual* move towards farming in general could be largely indigenous in origin – perhaps the real migrants were largely just new ideas, skills, and ways of "going on" in the world.

An important component of this current model of the Neolithic regards concepts of tenure, and the location of funerary monuments within the landscape. For people who are essentially mobile for much of the year, tenure over any land could well be conceived more in terms of "rights of access" rather than specific "ownership" (Barnatt 1996a, Ingold 1986). Moreover, tenure of any given area may not necessarily be exclusively held by any one "group" at any fixed time, but rather would be negotiated and shared via a complex of fluid and dynamic social relations. Part of these complex negotiations of tenure may have been to make reference to one's ancestral past, symbolised by an ancestral presence in the landscape, situated within burial mounds. This is quite different from Renfrew's ideas of Neolithic "territories" in Wessex, which he argued were delineated by barrows, as such a simplistic territorial function would lack relevance in a land without ownership (c.f. Renfrew 1973). Rather than being sited to act as boundaries, they may have been located along important pathways through the landscape, to be encountered with the unfolding of the long established seasonal (Barrett 1988, 1984, Bradley 1984, 1993, 1998, Edmonds 1999a, Pollard 1999, Tilley 1994, Thomas 1991, 1996, 1999, Whittle 1996, 1997).

2.3.2 – Reappraisal of Old Evidence

Barnatt's 1996 paper achieves two key aims (1996a). Firstly, it challenges some long held misconceptions about later prehistory in the Peak. Secondly, it successfully provides a synthesis of data, both old and new, which firmly situates the region within current Neolithic and Bronze Age interpretative agendas. It is largely within the context of this work (and more latterly Edmonds and Seaborne 2001), that the analytical research presented in this thesis sits.

2.3.2.1 - Monuments and Surface Scatters in the White Peak

In the first part of this paper he aims to address what he saw as the long held misconception that the White Peak was the core of settlement activity during the Neolithic, with the Eastern Moors being either ignored, or at best, peripheral during this time. He starts this deconstruction by critical evaluation of existing data, and much of his argument revolves around zonal differences in evidence that create "known but unreconstructable biases" (ibid: 48). In cases where these biases have already been explored above, they will be briefly summarised below.

The first problematic area in existing data resides with the Neolithic funerary monuments, which Barnatt acknowledges are exclusively confined to the

White Peak. Summarised in section 2.1.2.1, all of these have suffered damaging intervention or destruction by Antiquarians or other agents, resulting in ambiguity over their numbers and typology (see also Barnatt and Collis 1996). Only parts of the Minninglow and Tideslow Great Barrows and the Green Low passage grave have been excavated using modern techniques (Marsden 1982, Radley and Plant 1971, Manby 1965). Excavations at Minninglow (Marsden 1982) offer a putative chronology, starting with simple closed chambers, followed by long barrows, then passage graves, and finally superseded by the Great Barrows (after Manby 1958). Although a useful chronology, and one to which the study will return in Chapter 4, we are reminded of the "caveat that there has only been limited excavation" and thus must treat it with some degree of caution (Barnatt 1996a: 46).

The second category of evidence for reappraisal is the wealth of lithics material gathered from across the region as a whole. Firstly, differences in historic land use patterns between the White and Dark Peak zones render any real comparison between them meaningless, with lithic evidence being relatively poor from the gritstone uplands. Secondly, methodological inconsistencies between surveying initiatives conducted over a number of years across the region introduce "known but unreconstructable biases" in the data, so even direct comparison between assemblages collected in the White Peak alone are problematic (ibid: 48, Garton 1991). Thirdly, many of the scatters recovered are complex palimpsests of material that dates from the Mesolithic through to the Bronze Age, and so are difficult to accurately date. Finally, interpreting assemblages as evidence of Neolithic settlement on the basis of leaf-shaped arrowheads, as did Bradley and Hart, is also spurious, as these artefacts are most likely to be lost *away* from settlement zones (unless of course there had been conflict). Recent advances in dating lithic artefacts have only been applied to a limited number of assemblages, from the Peak, including those from Mount Pleasant, Roystone Grange, and more recent surface collection discussed below (Barnatt 1996a).

A specific form of lithic evidence that should be diagnostic of Neolithic activity in the region comes from over 80 polished stone axes (or fragments of) that have been recovered from across the region (Moore and Cummins 1974, McK Clough and Cummins 1988). Unfortunately the distributions of these are subject to the same biases as for other lithic data as above, and in many cases, their provenance is only recorded to four-figure grid reference accuracy. Bradley and Hart used this material in assessing Hawke-Smith's earlier land use models, and concluded that their distribution corresponded with that of land suitable for arable farming in the Neolithic (Bradley and Hart 1983). This however is problematic (Barnatt 1996a).

Because of inaccuracies and problems with Hawke-Smith's land use facets (see 2.2.5.1 above), and inaccuracies in the provenance of many of these stone axes, Barnatt chose to reanalyse this data from scratch. Using only those axes or fragments provenanced with a minimum of six-figure accuracy (43 in total), he plotted these against his own version of Hawke-Smiths land facets, which he reconstructed from Hawke-Smith's original text, rather than relying on the inadequate land facet maps used by Bradley and Hart. Only two of the 43 were located on lower lying shelves that would be most ideal for agriculture. Whilst another 13 were found on very high ridge-tops, with soil too thin for cultivation, the vast majority were from areas whose suitability for arable farming is hard to assess without detailed soil mapping. Barnatt suggests that this more general distribution reflects broad woodland clearance across the landscape throughout the Neolithic. These clearances would be relatively small scale at any given time, and that these could have been used to facilitate grazing or the creation of arable plots. This is supported by what limited environmental evidence that exists for this zone, discussed further below (Barnatt 1996a).

Another category of potentially diagnostic Neolithic artefacts considered by Bradley and Hart were the "Macehead Complex" type, which seemed to be concentrated around Arbor Low. Some of these were recovered from surface collection, and others were recovered from burials, and for Barnatt, along with the ambiguities over which land facet this area falls into, this brings together a sufficient number of biases to preclude any further reassessment. As such he implicitly refutes this evidence.

2.3.2.2 - Environmental Evidence

Finally, over and above general *concerns with his methodology,* Hawke-Smith's environmental reconstructions can be questioned in the light of new evidence. In summary, Hawke-Smith proposed that the White Peak was dominated by woodland in the earlier part of the Neolithic, with the higher areas being used for seasonal pasture; and that woodland clearance became more extensive throughout the Later Neolithic. Recent analysis of pollen remains from two sites in Lathkill Dale show quite sudden disturbance of mature woodland, which has been carbon dated to circa 3,200 BC (Taylor et al 1994). This itself may have been preceded by at least one temporary clearance phase around 3,600 BC. Although Gramineae (grass and/or cereal) pollen are common after the later clearance phase, none were from domesticated species, leading the authors to conclude that "the main driving force may have been the need for pasture, rather than land for crops" (ibid: 361). Evidence for late Mesolithic and Early Neolithic clearance was also found from pollen remains around Lismore Fields in Buxton (Wiltshire and Edwards 1993). Samples from around this Neolithic site (discussed below) indicate the possibility of clearance occurring from the late Mesolithic, and incredibly, the *possibility* of cereal cultivation dating from around 4,000 BC. This new data lends support to Barnatt's suggestion that the distribution of stone axes reflects areas of clearance rather than cultivation *per se*.

Environmental evidence from the White Peak as a whole is very poor, and is worth placing in context with the rather better data from the Eastern Moors. A number of small-scale sporadic clearance activities throughout the Neolithic were recorded from a number of pollen cores taken from the gritstone Eastern Moors by Sheila Hicks (Hicks 1971, 1972). This also demonstrated the possibility of cereal cultivation from an undated horizon (A1) in her Totley Moss core, as indicated by the indicator species *Plantago lanceolata*, as well as possible cereal pollen grains. This evidence again challenges the previously held view that the gritstone Eastern Moors were somehow ignored during the Neolithic. Evidence for even earlier clearance during the Mesolithic has also been demonstrated for this latter zone (Mellars 1976, Tallis 1991). Whilst this evidence cannot be directly translated to the White Peak for taphonomic reasons (Garton 1991), it is possible that similar activities were taking place within the limestone plateau (Barnatt 1996a). Being at altitudes close to and above the tree-line, woodland that had been cleared by any means (anthropogenic or natural) may not have fully regenerated in the higher parts of the limestone plateau. Barnatt suggests that this would make these upland zones attractive to Neolithic pastoralists, who would visit them as part of the seasonal round. Both bodies of recent evidence concur with Hawke-Smith's idea that woodland clearance became more extensive throughout the Later Neolithic, remaining effectively permanent after circa 2,100 BC (Wiltshire and Edwards 1993, Taylor et al 1994).

Of chief significance here, is Barnatt's statement that there is also much evidence for Late Mesolithic activity in these same areas, and most significantly to our current models, that the Neolithic subsistence base and life style very closely mirrored that of the Late Mesolithic, but with wild hordes being supplanted by domesticated herds. As regards plant resources, we are probably talking about pastoralists with an interest in keeping the odd allotment, rather than weavers of grain baskets whose surpluses fed armies of monument builders.

2.3.3 Beyond the Plateau – Later Prehistory and the Gritstone Eastern Moors

In the next main section of this paper, Barnatt presents a range of important new evidence for Neolithic activity away from the limestone White Peak, on the gritstone Eastern Moors. Although the ceremonial monuments of the White Peak provide the main focus for this thesis, this new evidence is important as it provides a broader context for the Neolithic of the region as a whole.

New Lithic Evidence

Recent surface survey has sought to address the zonal biases present in the collection of surface lithic material across the region, as discussed above. This was achieved by conducting fieldwalking in 29 fields over a 22km long transect, running from Hartington to Bakewell. The transect deliberately traversed areas from the White Peak, the Derwent Valley, and up on to the Eastern Moors, and focussed on land that been subject to equal amounts of ploughing in recent times (Myers 1991, Hind 2000).

The survey generated some important observations. Firstly, there was further widespread evidence for Later Mesolithic activity across more of the limestone White Peak than earlier recognised, and this fact has also come to light as a result of other subsequent survey work in the area (Hind 2000). Secondly, many assemblages collected from the Derwent Valley and the Eastern Moors are attributable to the Early Neolithic, and that the distribution of artefacts from this period is broadly very similar to those of the Later Mesolithic. Thirdly, the new work showed that many assemblages were palimpsests of a wide chronological range of material, in which the enormous proportions of Later Neolithic material often appeared to "mask" materials from the Early Neolithic and Last Mesolithic. Fourthly there seemed to be a reduced amount of Later Neolithic material recovered from the main valley zones compared to the White Peak and gritstone East Moors (Barnatt 1996a).

Related to this new survey is the re-examination of some of the lithic artefacts described in sections 2.2.3, and 2.2.5.2 above. Of the 80 or so known polished stone axes recovered from the area, 10 are from the Eastern Moors (Moore and Cummins 1974, McK Clough and Cummins 1988). In addition, analysis of the lithics from the Swine Sty settlement, originally dated as Bronze Age, suggests that some may be Later Neolithic (Garton and Beswick in prep).

Rock Art

Another form of likely Neolithic evidence is found in prehistoric rock carvings. These have recently been re-catalogued by Barnatt et al (2002), and all occur in the main river valleys, or on the gritstone Eastern Moors. Often in the absence of any stratigraphically dateable material, these carvings are difficult to date, although some authors suggests that these are Neolithic in origin, for two reasons (Bradley 1997). Firstly, stylistically similar designs have been found carved on external kerbing stones and interior architectural components of the enormous Neolithic passage grave at Newgrange, in the Irish Boyne Valley (ibid). Secondly, a number of these carvings have been removed from their original locations and incorporated into Later Neolithic and Early Bronze Age monuments. Good examples of this later incorporation can be seen at Stanage barrow, on Eyam Moor, and the Barbrook II stone circle on Big Moor (Barnatt and Reeder 1982, Barnatt et al 2003, Edmonds and Seaborne 2001).

The specific interpretation of these abstract symbols is elusive and precarious (Edmonds and Seaborne 2001). Ethnographic evidence suggests that these designs, which are never figurative, may act "as metaphors for very complex ideas about the social, natural and supernatural worlds" (Bradley 1997, 10). In many cases, both in the Peak District and other parts of Britain, they are located on boundaries between upland and lowland zones, perhaps containing meaningful information to be encountered as part of the seasonal round (Barnatt 1996a, Edmonds and Seaborne 2001).

A Housing Estate in Buxton

Excavations conducted in the market town of Buxton, by Daryl Garton and the Trent and Peak Archaeological Trust during the mid 1980s, uncovered what is some quite unique Neolithic evidence. After discovering a scatter of Mesolithic material, subsequent excavations revealed some Neolithic pits, a ring of posts, a range of Neolithic artefacts, and cache of carbonised emmer wheat and associated chaff. In addition to this, most remarkable was the discovery of two substantial timber structures, measuring 15m x 5m and 7.5m and 5.5m for Buildings I and II respectively. Such Neolithic structures are very rare for the whole of Britain, and completely absent anywhere else in the Peak District (Pollard 1999, Thomas 1996). During excavation, Garton attributed a Neolithic date to the structures on the basis of Grimston Ware sherds and a Group VI axe flake recovered from Building I. Subsequent radiocarbon dating yielded calibrated dates of 3700–3105 BC and 3900-3375 BC for Buildings I and II respectively. Taking these dates to their extremes could suggest occupation that spans most of the fourth millennium, and alongside the cereal remains this could be suggestive of sedentary Neolithic arable subsistence (Garton 1991). This is the conclusion reached by Garton, and although Barnatt does not refute this interpretation, it is worthy of critique on several grounds.

Firstly, the presence of two buildings cannot be simply equated to evidence of permanent settlement. Equating the presence of buildings with permanent settlement is as much based on a historical hangover from the "Neolithic package" as it is irrefutable evidence (Thomas 1996). Such structures may be more indicative of some specialised function, such as a meeting point, or focus for ritual depositional activities (ibid, Thomas 1999). Secondly, a paucity of structural and stratigraphic evidence makes it impossible to demonstrate that the two buildings were contemporary. This, combined with the significant error margins for both radiocarbon dates, could mitigate against interpreting the site as one extended and/or permanent settlement. Thirdly, it seems unlikely that such timber structures could have survived for the durations suggested by Garton. Finally, the excavation trench of 100m x 50m only represents a very small keyhole into a deposit that stretches over hectares. A far greater area would need to have been excavated to assess how representative these structures were.

Although there is no doubt that this evidence indicates the presence of Neolithic timber structures and cereal remains at Lismore Fields, caution needs to be exercised in interpreting this as evidence for a unitary model of sedentary agriculture. As with other parts of Britain, it is likely that there were a variety of settlement practices taking place in the Neolithic of the Peak (Pollard 1999). Although evidence of repairs to the buildings at Lismore fields suggests ongoing use of this locale through time (ibid), this also needs to be balanced against the rather more common evidence for more transitory forms of settlement as indicated by lithic scatters (Barnatt 1996a, Edmonds and Seaborne 2001, Hind 2000). People were using different parts of the landscape in different ways.

The reappraisal of old data, along with evidence from the last 20 years enabled Barnatt to successfully reject the previously held core/periphery model. Having dispensed with this, Barnatt was then able to situate all this evidence within more contemporary models.

2.3.3 Monuments and Mobility in the Peak District Landscape

As opposed to the traditional core/periphery model, Barnatt sees the Peak District's varied landscape zones as offering "a significant variety of topographies, each of which had different range of viable hunting, gathering, and agricultural options that could be sensibly exploited" (1996a: 46). As such, all of the landscape zones outlined in 2.1.2 above were utilised, and even those places visited rarely or by few people would still have a significant place in the cultural landscape.

During the Neolithic, movement throughout the landscape of the Peak would have had a seasonal basis. Certainly on the limestone White Peak, this movement would have been along pathways linking upland pastures, with these pathways themselves already having a history reaching back into the Mesolithic. Much of this upland grazing land may have been shared out amongst a number of different (possibly kin) groups, for whom any real concept of ownership failed to exist (ibid).

The Neolithic burial mounds of the White Peak would have been of profound importance to its Neolithic seasonal visitors for a number of reasons. Firstly by associating themselves with the monuments, the presence of monuments would also associate those who visited them with places that must have held some special cultural "meaning". Secondly, by the burial and containment of their ancestors, the monuments gave a sense of a timeless connection between the present and the past, and added legitimacy to the present inhabitants rights of tenure and access to the land. Thirdly, this link with the ancestral past could have been potentially strengthened by the subsequent addition of the more recently deceased, possibly from one's own kin group. Fourthly, the prominent locations that many of these monuments have made them highly visible symbols of the presence of the ancestors, overlooking the lives of the living as they were played out against a backdrop of thousands of years of history. Again, these are general themes articulated by many authors over the last 20 years.

The location of these monuments in the landscape is unlikely to be random, and the specific details of these are discussed further in Chapter 4. Important to this general argument is that as elsewhere in Britain, several of these monuments are placed in locales that are likely to have been of significance stretching back into the Mesolithic. Located near ridge tops and watershed boundaries, they would be close to pathways followed as part of the seasonal round. Here people would be more likely to encounter others, and therefore the more likely it is they would need to have recourse to reaffirming their ancestral tenure over these upper grazing areas (ibid).

Moving into the Later Neolithic, things begin to change. Firstly, as noted at many other parallel monuments in Britain, seven of the earlier Neolithic burial mounds become modified into what Barnatt terms the Great Barrows (after Manby 1958). This entails embellishing the overall physical size, and equally importantly, removing access to the passages, chambers, and ultimately bones of the ancestors within. Now the emphasis is placed firmly on the areas outside of these Great Barrows, rather than any proceedings within. This shifting of focus away from the ancestors themselves, to a "performative zone" outside of the barrows is a highly significant development in itself (Barnatt 1996a, Barrett 1994, Edmonds 1999a, Thomas 1999). As monuments survived for longer than anyone individual's lifetime, their meanings may change over many generations. This creates a situation where opportunist individuals or groups can manipulate and corrupt these meanings to their own ends. By assuming a position of power and authority these individuals or groups can refer back to the ancestral past to legitimise their claims, without allowing direct contact and interaction with it (Barrett 1994). This can be seen as one of the initial indicators of an emergent social differentiation not evident for the earlier half of the Neolithic, and Barnatt argues this point here (1996a).

Secondly, the Late Neolithic witnesses the emergence of a whole new form of monumental architecture – the henge monuments, at Arbor Low and the Bull Ring. These circular monuments would structure proceedings in a manner very different from those encountered at tombs. Their characteristic circular bank and ditch structures were designed to enclose people within a certain space, precluding any real view of the world beyond, except through their entrance and exit (Barrett 1994, Bradley 1998, Edmonds 1999a, Richards 1996). Acting again as supra-regional centres, one assumes more people would visit the monument at certain times than could practicably fit inside, suggesting that there may have some level of social differentiation dictating who could participate within the circle, and who would remain as onlookers from outside. This theory is further strengthened by the ongoing discovery of exotic lithic artefacts from the areas immediately around Arbor Low, where recent surface survey has recovered further evidence of polished stone axes/fragments, and fine Wolds translucent flint (Arteamus unpublished survey).

Barnatt describes these great barrows and henges as comprising groups of "monument complexes", which he aggregates into five main groups, summarised in Table 2.1 below (1996a):

Location	Monuments in complex
North West	Bull Ring henge
North East	Tideslow great barrow
Central	Arbor Low henge, Ringham Low and Bole Hill great barrows
South West	Long Low bank barrow, Pea Low great barrow
South East	Minninglow and Stoney Low great barrows

Table 2.1 Later Neolithic Monument Complexes, after Barnatt 1996a

Barnatt again comments on their location in the landscape, stating that, "It is hard to dismiss the repetitive spacing between these five monument groups as coincidence, as it contrasts with the distributions that went before and because similar patterns recur over large parts of Britain" (ibid 52). Barnatt also suggests that the monuments within each complex were connected by well established pathways or routes, to which he attributes sacred status. As these monuments were required to accommodate more participants over time, their need to be in prominent locations would have become more apparent, and this could have been a major driving factor behind choosing which monuments became embellished, and which fell out of use. This will also be addressed using viewshed analysis in Chapter 4.

In summary, as in many parts of Britain, the Later Neolithic of the Peak District starts to exhibit signs of emergent social differentiation, as evidenced by changes in mortuary practices, and the building of new types of monument. One final type of new monument that started to emerge in the Later Neolithic was the single unchambered round barrow. Often only containing single individuals, this again shows a change in mortuary practices that seem to emphasise the individual rather than the communal. The economy was still largely pastoral, based around the seasonal grazing grounds established a millennium or more before, although arable farming could have been becoming more significant through time. The increase in arable farming would have lead people to lead a more sedentary lifestyle than in the Early Neolithic. The creation of much larger monuments suggests that people were coming together in larger groups, and certainly the henge monument at Arbor Low could have provided an arena in which people could gather from across the whole region and beyond. The world was definitely changing, albeit gradually, and by the time we enter the Early Bronze Age, meaning in the landscape starts to develop whole new forms (ibid, Edmonds and Seaborne 2001).

His model concludes by hypothesising how the different landscape zones described in section 2.1.2 were not just exploited in the past, but also how they were perceived by their largely mobile inhabitants. As such it introduces a real sense of "human scale" to our understanding of later Peak prehistory that had hitherto been sadly lacking. These are summarised as follows:

The Shale Valleys and Lower Limestone Shelves

Shelter afforded by the valleys would make them suitable as home bases for over-wintering. The lower limestone shelves would have been well suited for limited cultivation. Long travelled pathways would lead to and from these locations. This was "home", and had been for millennia.

The Higher Limestone Plateau (White Peak)

After the onset of sporadic woodland clearance from the late Mesolithic, this zone would have been ideal for seasonal upland animal grazing. With people entering this zone from the surrounding valleys in all directions, traversing this area would have entailed the uncertainty of encountering strangers. It was here that tenure needed to be negotiated with others, and this would have been resolved by reference to the ancestors and ritual proceedings conducted at monuments.

The Eastern and South-Western Gritstone Uplands

Although considered marginal today, in prehistory these would have had fertile soil suitable for cultivation. This is demonstrated by the numerous Bronze Age field systems observable today, and these would have truncated any earlier evidence of Neolithic farming (Barnatt 1996a, 1999, 2000). Exploiting this zone would entail less uncertainty than the limestone White Peak, with each group identifying its own traditional area.

The Northern Massif

This area witnessed the onset of peat formation at the end of the Mesolithic, although this was sporadic and localised, with the current "blanket bog" only being fully established by the Iron Age (Tallis and Switsur 1983). Areas would still have been heavily wooded during the Neolithic, and would have been suitable for extensive hunting. Perryfoot, the northern most Neolithic barrow in the Peak, contained a diverse assemblage of wild and domesticated animal bones, possibly attesting to the importance of this activity (Pennington 1877). For many it may have been a liminal zone, perhaps only rarely visited for symbolic and ritual purposes such as rites of passage, or other activities.

Taken together, these zones constitute "complementary characteristics and resources" allowing a diversity of settlement, subsistence and social practices. Although much of the population may have been "on the move" for much of the time, there would also be those for whom stasis was desirable or necessary. Potential settlement such as that suggested by the evidence at Lismore Fields could be an example of the kinds of "home bases" Barnatt suggests for the River valleys and lowland limestone shelves.

Overall, Barnatt's 1996 paper is an excellent piece of work that has brought a very timely re-appraisal of both old and new evidence, dispelled some old misconceptions, and firmly situated our understanding of later prehistory in the Peak into the current archaeological paradigm

2.4 The current state and future questions for the rest of this thesis.

The most recent publication to describe Prehistory in the Peak was from Edmonds and Seaborne (2001). Although not intended to be an academic work in any traditional sense (Edmonds pers comm) it does extemporise lavishly on the recent works of Barnatt. Accompanied by Seaborne's often breathless imagery, Edmonds's text develops the themes of mobility, lineage, ancestry and phenomenology he had previously explored in his more recent general works. Using a style of narrative similar to his "Ancestral Geographies of the Neolithic" (1991), Edmonds's account is based on current archaeological thinking, but again is discussed in a highly humanised and personal way, full of suggestions about how life was *experienced* in prehistory, rather than just the bare mechanics of how it *functioned*. In general, it concurs with much of Barnatt's recent work, although questions some of the details of his interpretations, such as his suggested early chronology for more sedentary farming.

Barnatt's model is not without some problems, and a number of questions do remain about the exact mode of settlement and subsistence during the Neolithic and Bronze Age in the upland areas of the Peak. Some of these can be partly addressed using the technologies explored in this thesis.

A major shortfall within the available evidence that directly affects this thesis is the lack of recent and reliable excavation evidence from the majority of the Neolithic burial mounds of the White Peak. As well as leaving ambiguities in the typological and chronological interpretations of these monuments, the lack of detailed structural, stratigraphic and artefactual evidence precludes developing some of the current themes that have been articulated for similar monuments across the rest of Britain. These are summarised in the next chapter.

With the notable exception of Lismore Fields, an overall lack of evidence from much of region still leaves unresolved questions over the location of more permanent settlement during the Neolithic, and the exact nature of seasonal movement throughout the region. For the Early Neolithic, it is unclear how tenure over the landscape of the White Peak was articulated by those travelling through it as part of the seasonal round, over and above the general principle that this was at least in part negotiated via reference to the presence of the ancestors in the landscape. (Barnatt 1996a, 1996b, Edmonds 1999a, Edmonds and Seaborne 2001). Equally unclear is the mechanism by which some burial mounds become embellished in the Later Neolithic, whilst others begin to fall out of use. In Chapter 4 GIS based viewshed analysis is employed to try and answer some of these questions.

Another Later Neolithic phenomenon is the emergence of the two henge monuments, and questions may be asked how these may have also operated at a supra regional scale, along with the Great Barrows. This again is examined in Chapter 4. Then, taking the "site" as the scale of analysis, the way that these monuments may have been experienced by individuals is explored in Chapters 6 and 7. Before this however, there will be a necessary introduction to GIS and the applications of viewshed analysis, and this is the topic of the next chapter.

Chapter 3 - Beyond the Map

3.1 Introduction

The aim of this chapter is to present a history and critique of the use of GIS based viewshed analysis in archaeology, as a precursor to the analytical work presented in Chapters 4, 6 and 7. In general terms, the use of GIS in archaeology has burgeoned within the last 15 years, since the publication of pioneering volumes such as Allen et al's "Interpreting Space" (1990a), and so a comprehensive critique and history of its broader use is beyond the scope of this discussion. For a more inclusive guide to the applications of GIS in archaeology, the reader is directed to the excellent "Spatial Technology and Archaeology" by David Wheatley and Mark Gillings (Wheatley and Gillings 2002).

Although focussing mainly on viewshed analysis (or "visibility studies"), the chapter will start with some basic definitions and a short history of GIS, along with some of its general uses within archaeology, so as to provide some necessary context. The bulk of the chapter will then be devoted to the history and critique of viewshed analysis within archaeology, drawing on relevant case studies and previous research.

3.1.1 - A Brief History and Key Definitions of GIS and Viewshed Analysis

The precursors of modern day GIS solutions date back to the 1950s and 1960s, and originate from a number of disciplines, notably ecology and landscape architecture. A very early example comes from the Institute of Terrestrial Ecology here in the UK, where a system of punch cards was used to store distribution data for around 2000 species of British plants, during the 1950s. Pioneering work in the 1960s came from the Harvard Laboratory for Computer Graphics, under the direction of architect and town planner, Howard Fisher. The Harvard lab produced several programs to interpolate data from a number of disparate sources to produce data "grids" (i.e. raster data sets), such as SYMAP, GRID and IMGRID, which could then be overlaid, and from which new data could be derived (Burrough 1986, Wheatley and Gillings 2002).

The first "real" GIS was developed in Canada during the 1960s, by the government's Regional Planning Information Systems Division, as a means to provide a means of managing inventories of forestry resources, and to predict the effects of their exploitation (Marble 1990). During the 1970s, several US governmental agencies started to develop their own systems for a number of tailor made applications, as a rapid increase in post-war redevelopment left planning departments struggling to keep up with demands placed upon them. The most notable of these is GRASS (Geographical Resources Analysis System), developed by the US military's Corps of Engineers, and has remained popular in many academic institutions for many years (e.g. Lake et al 1998 JAS 25). The first commercial solution came from ESRI (Environmental Systems Research Institute), and their products are very widely used today, especially within academic research (Wheatley and Gillings 2002).

Current GIS systems are sufficiently diverse and sophisticated to defy any one simple definition, although they generally refer to software packages comprising the following features:

1. A searchable database of spatially referenced features (e.g. sites or individual artefacts) with associated a series of non-spatial attributes (e.g. period, artefact type)

2. A graphical map based interface on which the above features can be displayed

3. A collection of analytical routines to interrogate the database or perform other functions to create new information

In some cases GIS systems entail the use of specialised hardware peripherals, often for inputting data (ibid, Madry 1990). The various ways that these are implemented technically, and the diversity of analyses that can be performed are again beyond the scope of this discussion, and again the reader is directed to a more inclusive or general work (Burrough 1986, Kvamme 1999, Wheatley and Gillings 2002).

Viewshed analysis is a specific analytical procedure found in many currently available GIS packages. Viewshed analysis allows the user to take a specified point or points in the landscape, and in combination with an elevation model of the landscape, the procedure will calculate which areas of that landscape are in view from the specified points. The elevation model is typically an array or grid of height values taken at fixed intervals, and is often called a Digital Elevation Model (DEM) or Digital Terrain Model (DTM). The results of the analysis are displayed as a new grid, corresponding in area to the source DEM/DTM, but with values coded as either 0 (areas not in view) or 1 (areas in view). This representation is known as a binary viewshed map. Viewsheds from two or more points can be combined using Cumulative Viewshed Analysis. In this case the resultant grid contains numbers corresponding to the number of points from which each location is visible (Wheatley 1995). The ascendancy in popularity of this form of analysis in archaeology is discussed below.

3.2 A Brief History and Summary of the Uses of GIS in Archaeology

3.2.1 The Attraction of GIS in Archaeology.

Although effectively a "tool from another discipline" (Zubrow 1990: 67), GIS systems are attractive to archaeologists for a number of reasons. Firstly, all archaeological data has a spatial provenance, whether it be a microlith or a causewayed enclosure. In addition, all archaeological entities have properties, or *attributes,* that help characterise them – lithics have/don't have retouch, passage graves have a Minimum Number of Individuals etc. Much of archaeological research at the scale that is now referred to as "Landscape" has for decades involved archaeologists plotting this information via maps, and trying to compare distributions of things, often distinguished by attribute, in order to create archaeological meaning. GIS, with its ability to accept different forms of data at different scales, and its capacity to manage, process and display this information via the interface of a map, has a massive potential audience (Wheatley and Gillings 2002). Archaeology as a discipline was quite quick to recognise this potential (e.g. Gaffney and Stancic 1991).

Secondly, the analytical routines included in most GIS packages allow the creation of new information. Typically these may include a range of statistical functions for the analysis of spatial distributions, various distance and "cost" based procedures, and terrain surface based functions such as viewshed analysis or hydrological modelling. Ironically, many of these are anchored in the more quantitative practices of the New Archaeology, and are derived from disciplines such as geography and ecology. By the time easily accessible desktop systems had become available, many of these procedures were becoming increasingly eschewed by the Post-Processual community (e.g. Shanks and Tilley 1987a, 1987b).

Thirdly, the proliferation of IT across the discipline means that archaeologists now generate more data, faster, and importantly, this data is originated and/or stored in the digital domain (c.f. Biswell et al 1995, Huggett 2000). This is particularly true in modern day fieldwork settings, and is becoming increasingly so as more traditional data sets go online e.g. from the Ordinance Survey.

The growth of the use of GIS in archaeology has been significant since 1990. Originally a very specialised discipline, publishing a few esoteric edited volumes (Aldenderfer and Maschner 1996, Allen et al 1990a, Gillings et al 1999, Lock 2000, Lock and Stancic 1995, Westcott and Brandon 2000) it is now starting to enter more mainstream archaeological literature and practice. The relatively recent publications of the Archaeology Data Service's "GIS Guide to Good Practice" (Gillings and Wise 1999), and "Spatial Technology and Archaeology" (Wheatley and Gillings 2002), along with themed sessions at conferences such as TAG are testaments to this (ibid, Lock 2003).

3.2.2 Summary of Uses In Archaeology

Kvamme (1989) has identified five key areas of GIS usage in archaeology, but for the purposes of this summary these can be condensed into two – Cultural Resource Management (CRM) and Landscape Archaeology (taken as analogous to "landscape analysis", after Lock 2003; 164).

3.2.2.1 Cultural Resource Management (CRM)

Typically, CRM applications harness the data handling and display functionality offered by GIS, often with statistical analysis functions being used in "Predictive Modelling". A detailed discussion of this application of GIS in archaeology is beyond the scope of this thesis, which concerns itself with the use of GIS in Landscape Archaeology.

3.2.2.2 Landscape Archaeology

The uses of GIS in Landscape Archaeology also capitalises on the technologies' data handling and display capabilities, but in addition arguably makes far more use of GIS abilities to generate new information (Green 1990b). This might be in novel ways of combining existing data, or using analytical techniques not readily practicable using analogue means e.g. viewshed analysis. The emphasis here is on interpreting existing data, rather than predicting where there might be more.

Typical applications in landscape studies might be the analysis of lithics from test pitting or field walking surveys, in which different types of artefact could be plotted on different "layers". Equally common are the uses of GIS to analyse the locations of monuments. This may be in relation to the same environmental factors utilised in CRM models above, but perhaps more importantly, in relation to other monuments and other forms of archaeological data. These analyses range from spatial statistics, the generation of Thiessen

Polygons and Site Catchment models (Vita-Finzi and Higgs 1970), through to more qualitative studies based around human cognition and experience, with these often being mediated via viewshed analysis. Early pioneering examples of applications in European landscape archaeology are Gaffney and Stancic's work on the island of Hvar (Gaffney and Stancic 1991), Lock and Harris's work around the Danebury area (Lock and Harris 1996) and Gillings's work on the Tisza valley in Hungary (Gillings 1995).

In epistemological terms, GIS publications in archaeology follow a similar trajectory as seen in Virtual Reality applications, as discussed in Chapter 5, and these can be summarised as follows:

1. Early Claims of potential
2. Early descriptions of projects and methodologies
3. Results of early pioneering work
4. A phase of criticality
5. A post-critical phase

Importantly, as with VR applications, this trajectory has not followed a strictly chronological pattern, so although David Wheatley started to raise concerns about predictive modelling in 1993, authors were still publishing its methodology and results 10 years later (Wheatley 1993 c.f. Hatzinikolaou et al 2003). Generally speaking, those works falling into the first three categories have latterly been attacked for their uncritical use of the methodology.

3.3 The Critique of GIS

The ascendancy of viewshed analysis within archaeology can be seen as a response to an emerging body of dissatisfaction with the directions that GIS based studies were starting to take in the early to mid 1990s. These were articulated by a number of practitioners within the discipline (Gaffney et al 1995, 1996, Gaffney and van Leusen 1995, Gillings and Goodrick 1996, Llobera 1996, Verhagen et al 1995, Wheatley 1993) and culminated with something of a post-processual backlash by the end of the 1990s (e.g. Witcher 1999). The emergent criticisms were broadly twofold.

Firstly, many early publications using GIS in archaeology focussed around the use of predictive modelling in CRM (Gaffney and van Leusen 1995). Because environmental variables are much easier to quantify and code in a GIS than social factors, many such predictive models are based around the correlation of sites with such environmental factors (ibid). This has led to the criticism that GIS encourages environmentally determinist accounts of the past (Gaffney et al 1995, 1996, Gillings and Goodrick 1996, Llobera 1996, Witcher 1999, Wheatley 1993, 2000, 2004). Predictive modelling also suffers from other serious and unresolved methodological problems beyond the scope of this discussion (Ebert 2000, Wheatley 2004, Woodman and Woodward 2002).

Secondly, GIS systems are based upon a fairly simplistic representation of Cartesian space (Brück 2005, Verhagen et al 1995, Wheatley 2000). In the New Archaeology, space was treated as a "neutral canvas on which cultural activity left traces" (Wheatley and Gillings 2002: 6), and archaeological data could be mapped in this Cartesian world in a non-problematic way. Recent post-processual accounts reject this view, and have started to emphasise space as an arena of cultural significance that both shapes, and is shaped by human experience, rather than just a neutral container for human action. Space is a place where moments of significance are written into the biographies of people's everyday lives, not just a meaningless environmental backdrop (Thomas 1993). As a great deal of this meaning arises as a result of the interaction with others, space can be seen as being as much *socially* created as it is environmentally (Bender 1993, Ingold 1994). More general critiques of GIS regard the display of information via the metaphor of the map (Gaffney et al 1996). These also apply to other forms of archaeological representation, such as the convention of the plan (Barrett 1994, Thomas 1993) and are discussed in more detail in Chapter 5.

Archaeologists were now demanding more subtle and complex engagements with space and time, and approaches to landscapes and monuments were being framed around human experience, as classically exemplified in Barrett's *Fragments From Antiquity* (1994) and Tilley's *A Phenomenology of Landscape* (1994). It is in the light of this that practitioners have turned to viewshed analysis, as a means of providing a more humanised GIS based analysis of archaeological data.

3.4 Viewshed Analysis

Over and above the strictly technical definition of viewshed analysis offered in 3.2.1 above, a more refined and inclusive definition referring to archaeological viewshed analysis has been provided by Wheatley and Gillings (2000).

> "Here the term visibility refers to past cognitive/perceptual acts that served to not only inform, structure and organise the location and form of cultural features, but also to choreograph practice within and around them. In keeping with the principal focus of existing investigations into the heuristic utility of visibility based approaches, the spatial context is that of the inhabited landscape". (ibid; 1)

They suggest that this visibility within the archaeological landscape might be in reference to other related monuments, significant natural features or environmental factors, periodic astronomical phenomena, or some combination of all three (ibid). Less easy to observe in the modern world could be social implications of visibility, for example how the viewshed from a burial mound *might* delineate a certain group's claim of tenure over the surrounding landscape.

If viewshed analysis is to be a relevant and/or useful, it is implicit that viewshed phenomena must have had some cultural significance to those who constructed monuments and experienced these landscapes in the past. This does not demand that the desire to create visibility phenomena was necessarily either a significant or the only important causal factor in the siting of monuments either (c.f. Fraser 1983, Woodman2000). Instead the viewshed from a given location might be better seen as an affordance provided to potential monument builders that would enable the structuring of meaning within the landscape. How the use of those affordances is interpreted needs to be driven by appropriate archaeological theory, within the context of relevant and coherent archaeological models. In this sense it may be true that purely exploratory uses of viewshed analysis are more satisfactory in archaeologically well documented and discussed areas (van Leusen 2002), such as the Peak District (Chapter 4, this volume), or the landscape around Stonehenge (Exon et al 2000).

Studies of visibility and viewsheds within archaeological landscapes are not new as a result of GIS technologies, but range from as far back as Antiquarian times, when Stukely commented on the "false cresting" of barrows in Wessex (Lock 2003, van Leusen 2002). Functionalist approaches to the locations of monuments have also invoked discussions of visibility in reference to defensive and territorial concerns (Fraser 1983, Renfrew 1979). More recent publications have sought to embrace the general criticisms of GIS presented above, and use viewshed studies to heuristically test or quantify the more experiential aspects of archaeological monuments and landscapes, and these are discussed throughout the rest of this chapter. It should also be noted during the last 15 years, visibility based studies have continued, from a phenomenological perspective. Arguably to their detriment (Fisher 1999), these studies have been undertaken without the use of GIS (Cummings 1999, 2000, 2002, Cummings et al 2002, Cummings and Whittle 2003, Thomas 1993, Tilley 1994).

3.4.1 Early Studies in Viewshed Analysis

Early publications in viewshed analysis mirror the more general developmental trajectory of GIS studies listed in section 3.2.2, showcasing the use of the technique, and demonstrating its future potential.

Gaffney and Stancic's pioneering work on the island of Hvar, in Dalmatia, heralded the first real application of GIS to landscape archaeology in Europe (Gaffney and Stancic 1991). Aiming to "introduce GIS to a wider audience in

Europe" (ibid:13), they employed something of a scattergun approach using a variety of analytical techniques. Part of this study included visibility studies to analyse the locations of watchtowers, built by the Greek invaders of the sixth century BC.

Ruggles et al published what is probably the first application of viewshed analysis in the UK, looking at the location of Bronze Age stone rows on the island of Mull (Ruggles et al 1993). Ruggles combined the viewsheds from multiple stone row sites, to indicate the total area in view from all sites (c.f. *cumulative* viewshed). This was used to identify significant features in the landscape that could have influenced the alignment of these linear rows. Viewsheds were then created from these natural features, and those containing the most stone row sites were considered the most significant (Fisher et al 1997).

Lock and Harris analysed the location of Neolithic long barrows, as part of a broader study around the Danebury area (Lock and Harris 1996). They interpreted these barrows as territorial markers (c.f. Renfrew 1973), and compared their viewsheds with Thiessen Polygons generated around their locations. None of the barrows were intervisible, i.e. none could be seen from any other, although some held "shared" views of the landscape. They concluded this phenomenon resulted from deliberate siting, with the viewsheds from the barrows providing senses of both prospect and refuge (Appleton 1996).

Gaffney et al's 1996 paper prefaced their study with the first attempt to situate GIS studies within their current theoretical climate, with Gaffney being one of the first authors to express concern over environmentally deterministic uses of GIS (Gaffney et al 1996, see also Gaffney et al 1995, Gaffney and van Leusen 1995). In the light of this they reinterpreted much of their earlier work on Hvar (c.f. Gaffney and Stancic 1991), which they themselves conceded had represented "an essentially environmentally deterministic approach" (Gaffney et al 1996: 140).

The second half of the paper presented new analysis, interrogating the locations of prehistoric Rock Art panels within the archaeologically diverse ritual landscape of Kilmartin. Using cumulative viewshed analysis, their aim was to provide a "mappable, spatially variable index of perception" and gain "an insight into the cognitive landscape within which the monuments operated" (ibid: 147). Their analysis was based within the theoretical framework of Bradley (Bradley 1991), suggesting that rock art panels present information about the landscape, occurring on the boundaries between upland and lowland zones, and near concentrations of other monuments. The viewsheds from the rock art panels included far fewer monuments than that of the henge at Ballymeanoch, suggesting the former have a more intimate sense of landscape setting than the latter.

David Wheatley was probably the first critic of environmentally deterministic GIS (Wheatley 1993). He used cumulative viewshed analysis (CVA) to compare and contrast the landscape settings of Neolithic tombs between the Stonehenge and Avebury regions (Wheatley 1995). Rather than providing a purely qualitative analysis, Wheatley quantitatively assessed their viewsheds, demonstrating that the intervisibility between the barrows around Stonehenge was statistically significant compared to a number of random non-site points. This pattern was not demonstrable around Avebury. Wheatley concluded that the Stonehenge barrows were deliberately sited so as to make reference to ancestral authorities present in earlier monuments, by analogy with the monuments around the Dorset Cursus (c.f. Barrett et al 1991). He suggested that around Avebury, the architectural configurations of the monuments themselves was of greater significance to their builders than the surrounding landscape or earlier monuments.

Llobera (1996) used a variation of Wheatley's CVA methodology to investigate Bronze Age linear ditches in Wessex. One of the most important features of this paper was his opening treatise on the relationship between GIS analysis and important recent paradigmatic shifts within landscape archaeology. Llobera demonstrated Bradley's earlier suggestion that ditch orientation closely mirrored changes in local topography in terms of aspect.

By combining multiple viewsheds from the same points, but calculated over progressively greater distances, he created gradient viewsheds from the ditches. Asymmetric gradients from either side of the ditches were interpreted as visibility boundaries, suggesting a directionality from which they were meant to be seen.

Critique

The first of the three papers above demonstrated the potential of viewshed analysis, and no doubt helped raise its profile within archaeology. All three however could now be accused as being uncritical or theoretically misguided. Gaffney and Stancic's work on Hvar was largely purely functional, Ruggles et al assumed a degree of causality between visibility and monument siting, and Lock and Harris based their analysis on a theoretical premise that is no longer held valid.

By the mid 1990s, authors were starting to apply some criticality to the use of the technique, and the second three papers demonstrate this in three main ways. Firstly, all three of these sought to critique earlier uses of the technology, and place their own studies within current archaeological paradigms. Secondly, they brought a degree of methodological rigour to their analyses, with Wheatley's study becoming a blueprint for many that followed (e.g. Joyce 1995, Llobera 1996, Fisher et al 1997). Thirdly, all three studies started to shift the focus of attention towards the landscape between the monuments, rather than just the monuments themselves (Crumley and Marquardt 1990). Space was no longer being treated as a neutral or abstract backdrop for human activity.

3.4.2 Problems with Viewshed Analysis

The above papers provide a sense of how GIS based visibility studies were developing towards the end of the 1990s. With an emerging body of literature, it was time to take stock. Some authors felt that the uncritical use of this technique has gone too far, with increases in the ease of use of GIS resulting in "a familiar sense of push-button functionality with no underlying archaeological purpose, as ever more papers become choked with ever more viewsheds" (Wheatley and Gillings 2000; 1)

In summarising the recent criticisms of viewshed analysis, Wheatley and Gillings have identified three key areas of concern: pragmatic, procedural, and theoretical (ibid). These are outlined below. Procedural issues apply specifically to GIS based viewshed analyses, with the other two categories applying to all visibility studies.

3.4.2.1 Pragmatic Problems.

Studies of visibility are based observation or computations over current landforms, and Digital Elevation Models pay no attention to current or past vegetation. Vegetation can have a profound effect on visibility, especially when very close to the viewpoint, and this is demonstrated in the cases of Green Low and Tideslow in Chapter 6. Although palaeoenvironmental data can provide a regional or quite local picture, it cannot identify individual stands of trees (Tschan et al 2000).

Issues of object-background clarity arise when considering viewsheds over long distances, and objects within a calculated viewshed may not actually be visible. Familiarity with the landscape might be necessary to resolve objects over long distance, although this may not be such an issue for mobile communities travelling as part of the seasonal round (Edmonds 1999a). Monuments constructed of chalk or limestone may themselves be highly visible, the equivalent of "the neon of their time" (Evans 1985: 84).

Visibility studies tend to present viewsheds calculated from a static point, and yet human perception is rarely static. Static viewsheds do not represent any sense of embodied movement throughout the landscape, nor do they pay any attention to how the architecture of a particular monument might structure movement, and therefore perception. In the ecological theory of perception (Gibson 1979), that has so influenced Ingold amongst others, movement is considered a fundamental component of perception (Ingold 2000, Wheatley and Gillings 2000).

Seasonal and diurnal environmental variations will affect visibility over different timescales. Over and above normal day/night differences, seasonal differences in vegetation and weather have a significant effect on both distance and clarity of view. Field observations in the Peak suggest that summer haze can attenuate view just as much as a winter mist, with stands of deciduous trees presenting a less permeable barrier to visibility in summer than winter.

Assuming that all points within the view of a given observer (views from) can equally see that observer (views to) is a flawed assumption, which has been documented in the field (Fraser 1983), and also within GIS based studies (Loots et al 1999, also Chapter 4 of this study). Equating "views to" and "views" from implies *intervisibility*, or reciprocity. This reciprocity may be a safer assumption over long distances, but obstructions close to either viewer (e.g. vegetation) will have a profound effect. Intervisibility cannot be assumed, but should be tested by calculating viewsheds from both points, and if necessary (as in marginal cases), substantiated with ground-truthing.

Reduction and simplification affects many studies in archaeology, when data becomes over simplified either temporally, typologically, or both. This is a real problem when the activities of Antiquarians or robbers leave a very impoverished archaeological record, as in the Peak District (Barnatt 1996a). In GIS terms, this can result in "complex diachronic landscapes being reduced to simple synchronic layers" (Wheatley and Gillings 2000; 8).

3.4.2.2 Procedural Critiques and Issues

The DEM is the primary data source that determines the outcome of a viewshed analysis, and so any errors or inaccuracies in this will have serious implications for visibility studies based upon it. Generally speaking, the higher the resolution of the DEM, the more accurate the analysis should be. Artefacts can occur in creating the DEM by interpolation, the process of creating the continuous surface from discrete points (Kvamme 1990). Typically these can include anomalous "spikes". Although these can be filtered out, this process may also smooth out natural features such as hillcrests or outcrops. As these features are often those that delineate viewshed boundaries (especially in the Peak District), perturbation of these is obviously problematic. Any errors within the DEM are propagated through any subsequent analytical procedures, and there is no simple correlation between DEM accuracy, and validity of the viewshed created from it (Wheatley 1995).

Although they may employ the same basic theoretical principles, different GIS packages implement viewshed analysis in slightly different ways (Cheng and Shih 1998). In some comparisons there can be differences in up to 50% of the visible area calculated, depending on DEM interpolation, and the algorithms used to compare different heights across the DEM.

The default output of a GIS derived viewshed is a binary image, where cells in view are coded with a value of "1", and those out of view with "0". Things are quite simply either in view or not. Given all the procedural and pragmatic issues listed above, this would now seem to be a little anachronistic, and Wheatley and Gillings argue "that there are potentially enormous levels of uncertainty inherent in any viewshed calculation" (Wheatley and Gillings 2000; 10). Rather than treating viewshed maps as an absolute opposition between in view and out of view, they should be treated more as probable viewsheds, and this can be modelled statistically using fuzzy logic and Monte Carlo simulations (e.g. Fisher 1995, Nackaerts et al 1999).

Some authors feel that heuristic and qualitative studies are of questionable value, and are only really significant when accompanied by quantitative studies of sufficient rigour (van Leusen 2002). This criticism could be levied at some of the papers presented above, as well as this study (Chapter 4). Although it is argued in this study that quantitative analysis is not *always* necessary to provide meaningful interpretative value, it certainly would be if trying to compare two different data sets. Wheatley's use of statistics to compare the barrows at Avebury and Stonehenge exemplifies this very well, and has become the de facto standard procedure for similar studies since (1995).

Issues of robustness and sensitivity relate to how we might address some of the pragmatic and procedural problems outlined above. Sensitivity testing involves the repeated calculation of the viewshed from a given point, whilst altering some of the key variables e.g. viewer height, or DEM resolution. An example of this can be seen in Lock and Harris's work at Danebury, wherein they performed repeated iterations with viewer heights ranging from two to four metres (Lock and Harris 1996); the comparison of DEM derived heights with actual height data obtained in the field is another (Nackaerts et al 1999).

Edge effects can occur when viewsheds are created for monuments, which for whatever reason, seem to extend beyond the edge of the study area (as delineated by the extent of the DEM). It can also occur for sites lying outside the study area (i.e. DEM), whose viewsheds have not been calculated, but whose viewsheds would otherwise naturally encroach upon this area (Van Leusen 1999). This is a potential problem when discussing areas such as the Peak District, where the concept of a "region" is dictated more by modern political boundaries than any one that had real meaning in prehistory.

3.4.2.3 Theoretical Critiques and Issues

The tendency for readily available functionality to dictate the directions of research has been described as "technological determinism" (Lock 2000), and it has been implicated as a reason why earlier GIS studies have engendered environmental determinism. This was also warned against by Allen et al (1990b). The ease in calculating viewsheds in contemporary GIS packages has provoked the criticism that many visibility studies may also be a product of technological determinism, rather than being based on sound theoretical imperatives.

Arguably the most fundamental problem with viewshed analysis is that it implies a direct equation between vision and perception, and doing so, succumbs to the problems of *visualism*, as outlined in 1.2.1. As discussed in the above section (1.2.1), the primacy of vision over the other senses may be a historical construct, whose origins lie in post-Renaissance landscape painting (Thomas 1993). Also implicit in many studies is the notion that seeing and looking are themselves abstract, timeless and value-free actions, rather than being culturally or politically contingent. It cannot be assumed that visual affordances presented to us by monuments today were responded to in the same way in the past, or in other words, vision cannot be taken as being purely objective (Brück 1998, 2005, Wheatley and Gillings 2000, 2002).

To reduce human perception simply to vision would of course be a massive over simplification of a process that is far more subtle and multi-dimensional. Perception should rather be seen as the complex interplay of the five physical senses – sight, hearing, smell, touch and taste. Non-western traditions would also emphasise the role of a sixth sense, that of consciousness, wherein the world is experienced not just in terms of these physical senses, but is also comprised of factors such as memory and experience (Rodaway 1994). An example that mitigates against visualism is that of the Umeda of Papua New Guinea (Gell 1995). Living in dense rainforest, members of this group rely predominantly on sound rather than vision, but again not to the exclusion of the other senses. Whilst the primacy of vision per se may not ultimately be problematic, as Mills states "we, as archaeologists, need to be more explicit about its role in the production of knowledge" (Mills 2000, 31).

The problem can be seen to go further, when perception is considered not just in terms of "receiving information", but as the act of deriving meaning and insight from the environment (Witcher 1999, Rodaway 1994) It is this form of perception that van Leusen defines as "cognition". For Witcher, "Visibility and cost surface analyses provide the information that is observed – but we need to think carefully about how we relate this to the actual mental insight, the perception, such information offered to past populations" (Witcher 1999: 16). The way meaning is ascribed to this perception is contingent upon the broader theoretical framework in which any given study is situated. It is for these reasons that it may be more appropriate to discuss visibility in terms of affordance rather than causation (c.f. Woodman 2000).

A final theoretical criticism of viewshed analysis echoes the broader critique applied to the GIS depiction of the world via the metaphor of the map. Rather than being situated in the perceived world, archaeologists looking at viewshed maps are doing so in an abstracted and disembodied sense, and are effectively "negating the essentially experiential nature of the perceptive act they are purporting to represent" (Gillings and Goodrick 1996; 1.4). To take an extreme quote from Thomas, they are treating the past perception of landscape like "a corpse under the pathologist's knife" (Thomas 1993; 25). What is required then are methodologies that can represent visibility data from a more embodied and situated perspective, and move beyond the "disjunction between two differing theoretical viewpoints" of phenomenology on the one hand, and the abstracted Cartesian portrayal of space on the other (Cummings et al 2002: 58). The representation of subjective phenomenological data in a meaningful and reproducible manner presents a challenge (ibid, Fleming 2005), and is further addressed in Chapter 5.

As outlined in Chapter 1, the problems encountered with both visualism and the map perspective are not just constrained to viewshed analysis, but have important implications for how archaeological landscapes and monuments are portrayed in broader terms. These are discussed in greater depth in Chapter 5, in reference to GIS studies and to representations of landscapes and monuments using Virtual Reality techniques.

3.5 Ravello and Beyond

Taking this "formidable body of critical considerations that must be addressed" (Wheatley and Gillings 2000: 13), visibility studies seemed to be in something of a crisis –archaeologists were not convinced of their ability to produce reliable viewshed data in the first place, and were not happy with their abilities to interpret what such data actually means. But many of the problems outlined are not unique to archaeological applications of GIS, with problems such as DEM error affecting all disciplines using the technology (Rajala 2004).

Rather than suggesting an abandonment of visibility studies, Wheatley and Gillings' comprehensive critique simply make explicit many of the factors to consider when looking at the results of viewshed analysis, and even in the light of these problems, they assert that "GIS-based approaches to the study of vision do have the potential to revolutionise our understandings of past landscapes" (Wheatley and Gillings 2000: 2). Instead, this work, along with others published in "Beyond the Map" represent a landmark in such studies, signalling a very significant "loss of innocence" within archaeological applications of GIS (e.g. Llobera 2000, Lock 2000, Tschan et al 2000).

Since Beyond the Map, a number of authors have sought to add methodological and/or theoretical enhancements to GIS-based visibility studies. Many contemporary practitioners of GIS seem to be aware of earlier problems, and it is now normal for recently published works to rehearse a review of these theoretical arguments (e.g. Llobera 1996, 2000, 2001, 2003, Roughley 2004, Rajala 2004, Trick 2004, Wheatley 2000, 2004). The rest of this chapter will consider some of these significant recent advances.

3.5.1 Higuchi and Directional Viewsheds

In the second half of their critique of viewshed analysis, Wheatley and Gillings (2000) suggested two possible enhancements to traditional forms of visibility studies. The first was based around the work of Japanese landscape architect and planner, Tadahiko Higuchi, whose influence had already been cited some 10 years earlier (Green 1990a). Higuchi identified eight factors that could be used to assess the viewshed from a given point. Wheatley and Gillings chose to investigate one of these in detail – the affect of increasing distance away from the observer on their visual experience. Rather than just describe the effect of distance in arbitrary terms, Higuchi wanted to quantify this in reference to a standard unit, for which in non-urban contexts he chose trees (importantly taking the height of the locally dominant tree species as the standard unit). Distances from the viewer were broken down into three bands:

1. Short-distance – at a distance of 60 times the height of the unit tree height, individual trees can be seen, including detail of leaves and branches.
2. Middle distance – described as the "pictorial landscape" (ibid: 15) – outlines of treetops can be resolved, but not individual trees.
3. Long-distance – broad areas of woodland can be resolved but little more. Now at a distance of 1,100 times the unit tree height, we are effectively looking at the horizon, acting as a "vertical backdrop" (ibid: 15).

Wheatley and Gillings provide a straightforward methodology for implementing this, summarised in Table 3.2 below:

1 – Create simple binary viewshed from the viewpoint
2 – Create a distance buffer from the same viewpoint
3 – Reclass the distance layer according to the three bands described above
4 – Multiply the viewshed from (1) with the reclassified distance layer from (3)

Table 3.2 – "Recipe" for a Higuchi Viewshed

This will result in a viewshed classified according to the three distance classes. A hypothetical application of this is suggested in reference to the siting of monuments in relation to earlier burial mounds, with boundaries between the three bands being described in terms of liminality and transition. Of course, the meaning we would ascribe to these three zones and the interfaces between them would, as ever, be contingent upon the broader theoretical context of the study in question. Once the relative size of these three bands has been determined, they can be graphically plotted and assessed statistically if required.

Following on from their exploration of the "Higuchi Viewshed", Wheatley and Gillings explore a methodology for assessing "directionality" of viewsheds. The suggested methodology for this is presented in Table 3.3 below

As with the Higuchi viewshed, the relative sizes of the resulting classes can be plotted and quantifiably assessed. Both techniques can be performed using simple "out of the box" functionality in either Idrisi or ArcView, and are demonstrated by using a case study of the Ridgeway in Wiltshire, although no real interpretation of the resulting data is provided.

1 – Create simple binary viewshed from the viewpoint
2 – Create a distance buffer from the same viewpoint
3 – Create an inverse of the distance buffer layer created in (2)
4 – Create an aspect layer from the inverted distance layer created in (3).
5 – Reclassify the aspect layer into cardinal directions if necessary (this would be done by default if using ArcView)
6 – Multiply the binary viewshed from (1) with the reclassified aspect layer created in (5)

Table 3.3 – "Recipe" for a directional viewshed

3.5.2 Modelling the Effects of Vegetation

Cited as a "pragmatic" issue by Wheatley and Gillings (2000), the effects of past vegetation on viewshed analysis has been tackled by Tschan et al (2000). Ignoring the impact of vegetation on visibility in the landscape is obviously erroneous, yet GIS based viewshed tools do not generally allow for the inclusion of this variable. Reconstructing past vegetational regimes that are sufficiently detailed to be very meaningful at a human scale is however problematic - pollen analysis has a raft of methodological and interpretative problems, and in this case, only regional rather than localised data was available. Despite this, the authors assert that "by the inclusion of information on past/present floral patterns the interpretation potential for any body of research is enhanced even when dealing with the most sparsely vegetated landscapes" (ibid: 34).

Their analysis was realised by adding a height of 20 to 30 metres to an existing DEM, at locations around a probable Mesolithic camp site in the Wrzesnica region of Poland. A viewshed analysis was performed using t6his modified DEM, and compared to a similar viewshed created without the reconstructed vegetation. The results were "fairly unsurprising" (ibid: 42), with the former showing virtually no visible areas beyond the immediate are of the site. What this study clearly shows is a real methodological problem with this kind of analysis – due to the raster data structure of the DEM, heights can only be modified down to the spatial resolution of the elevation data. This means that for example, a raster DEM with a 50 metre cell size, when modified with vegetation data, would end up with monolithic 50 metre square blocks extruded from the ground surface. This results in placing an impenetrable barrier around the site, and is clearly too crude for the more "permeable" open woodland as indicated by their palynological data. The problem is exacerbated by the undifferentiated binary nature of the viewshed produced. A more subjective approach might be to use landscape visualisation software that allows for more permeable woodland creation.

3.5.3 Prominence and Visualscapes

Like the formation of Higuchi and Directional viewsheds, Llobera's work in trying to understand the concepts of "topographic prominence", and the more inclusive notion of "visualscapes", represent methodological attempts to enhance visibility studies above and beyond the production of standard binary viewshed maps (Llobera 2001, 2003). In the first of these two studies, Llobera seeks to determine how a particular affordance of the landscape, topographic prominence, could be implicated in the socialisation process, in which "socialisation is understood as the process by which an individual becomes an integral member of society" (Llobera 2001: 1007).
Topographic prominence is defined as the proportion of locations around a given observer whose elevation is below that of the observer. It is calculated

for a given radius and is therefore a relative value depending on this radius. Relative prominence at a location can be equated to notions of hierarchy and rank, with locations of greater prominence being afforded the possibility of visual control over those of lower prominence. An exploratory case study, based around the Yorkshire Wolds, Bronze Age barrows appear to occupy locations of quite high prominence, at quite large radii (510 metres), suggesting they would be clearly visible over this scale of distance, and that this in turn might suggest they have both funerary and territorial roles. This is less so with later Iron Age "square" barrows, of which more occur at less prominent locations.

In the second of these two papers, Llobera attempts to reach a more unifying description of visual space, as can be resolved by GIS, which he terms the "visualscape" (2003). In addition to simply stating whether an object is visible or not from a given location, a visualscape might also incorporate features such as how much of the object can be seen, how large it appears, and how the view of the object may change as an observer approaches is it. Standard or cumulative viewshed analysis allow for the assessment for one component of the visualscape, as does topographic prominence as described above.

"Visual exposure" is introduced as a means of quantifying how much of, and how large an object or landscape feature appears to a given observer. This can be quantified by the horizontal and vertical degrees the object occupies from a given field of view. Deriving these values from a number of locations in a landscape can also then give a sense of directionality, the following of which will cause the object's visual exposure to either increase or decrease.

Both papers provide important new insights into which the visual characteristics of objects and landscapes can be described and quantified, although at this stage they are only really presented in theoretical terms, with no real archaeological application yet published.

3.5.4 The Neolithic Landscape of the Carnac Region

Corinne Roughley used a range of GIS techniques to explore the relationships between burial monuments and their surrounding locales in the enormously rich Neolithic landscape around Carnac, Brittany (Roughley 2001). In particular, her studies focus on the nature of the landforms around monuments, and how these would structure experience around these locations in terms of approaching and leaving tombs. Importantly, because of modern land use patterns, the GIS allowed analysis that would not be possible by conventional field based visibility studies.

The first part of her 2001 publication looks at how GIS can be used to automatically isolate certain geographic features in the landscape, particularly hills and promontories, so as to help quantify some subjective observations made in the field. As a result of some preliminary enquiries taking a sub-sample of the region, she noted that 71% of the later passage graves in the study occurred on either hills or promontories as identified by the analysis. Following this up with actual viewshed analysis comparing 43 early Neolithic earthen long barrows and a similar number of later passage graves against a random sample of 500 points in the landscape, differences between the two were identified. After buffering the viewsheds into 5 distance bands, the earlier long barrows appeared to have larger viewsheds than expected at a local scale, but not much larger than the background sample at wider scales.

Conversely, the later passage graves had much smaller viewsheds at the more local scale, but commanded much larger viewsheds at the wider landscape scale, confirming her field observations that they "are visible from a wide area, over large distances, but tend to disappear as you approach them, and reappear only when you are closer to them" (ibid: 215). This she interprets as the passage graves being chosen to be more widely visible in the landscape than the long barrows, which she suggests had a more local focus. Interestingly, she also noticed some correlation with the directionality of the viewshed and the orientation of the passage graves, suggesting that the largest uninterrupted viewshed would be encountered when exiting from the passage. This in turn suggests that the landscape setting of the passage graves structures experience at two scales – large visibility over a wide area, and a more intimate sense of encounter at the very local scale. It would be interesting to enhance this analysis with the more formalised Higuchi and Directional methods suggested by Wheatley and Gillings, along with Llobera's work on topographic prominence and visual exposure (Wheatley and Gillings 2000; Llobera 2001, 2003).

An important enhancement to her GIS based analysis was to provide an interactive representation of the landscape using Virtual Reality Modelling Language (VRML). This non-immersive Virtual Reality representation allows the viewer to heuristically test the findings of the viewshed analysis in an embodied and subjective manner (Roughley 2004, Roughley and Shell 2004). Not only does this offer a departure from the map based interface of the GIS, but also goes some way to answer the wider problems of adequately representing subjective studies of the landscape (Tilley 1994, Cummings 2000, Cummings et al 2002, Fleming 1999, 2005).

3.5.5 Viewsheds and Dwelling around Southern Romanian Neolithic Tells

Steven Trick uses a range of analytical and visualisation techniques to broaden the traditional "site based" approach taken to Neolithic tells (2004). In doing so he aims to situate them in a broader landscape and theoretical context, and "simulate the experience of the embodied viewing subject" to provide a phenomenological perspective (ibid: 1.0). GIS analysis initially comprised standard binary viewshed analysis from the *bases* of the sample sites (i.e. *not* their elevated tops). Considering their raw undifferentiated format to be too coarse, Trick then implemented both Higuchi and Directional viewshed analyses, as described by Wheatley and Gillings (2000). Most of the visibility from the tells was concentrated within the medium-distance Higuchi band, and with little representation in the long-distance band, visibility was quite clear, and confined to the river valleys. Trends in the Directional viewsheds suggest that not only is visibility confined to these valleys, but is also *focused upon them*, and that "since these valleys only comprise 16% of the total study area, tell vision could be said to inhabit small, micro worlds of experience" (Trick 2004, 8.1)

The affordances made available by the locations of the sites, for Trick, "set up a particular way of habitually viewing the world" (ibid: 8.1). Rather than gazing aimlessly at their world, tell inhabitants would be actively seeking out important information (Gibson 1979), and in doing so conduct "a practical act on behalf of subjects situated in, and engaging with an environment" (ibid: 10). This practical action is implicitly linked to Heidegger's "relations of concern" (ibid: 10), in which the world that can be seen has more relevance than that which cannot. Ethnographic evidence supporting this close habitual visual monitoring of events within floodplain systems has been attested to by the Paruaros of Brazil. By drawing upon the work of Heidegger, and also by using panoramic photography to provide a more situated record of the visual tell environment, Trick has managed to firmly situate GIS data and interpretation within a contemporary phenomenological framework.

3.5.6 Visibility and Movement in East Yorkshire

The movement of an organism is a fundamental component of its perception (Gibson 1979), yet most visibility studies present data in a static disembodied map format (Wheatley and Gillings 2000). Henry Chapman has illustrated how viewshed analysis can be enhanced by considerations of movement through two prehistoric landscapes in East Yorkshire (2000). In the first of these he used archaeological and palaeoenvironmental data to reconstruct a wetland landscape (recently damaged by drainage for peat cutting) at Sutton Common, containing two ploughed out Iron Age enclosures (Chapman 2000). Using the reconstruction of the banks and ditches from the two enclosures, he was able to model changing visibility whilst traversing along a putative journey from the smaller to the larger of these two monuments, showing "how the site architecture and the environmental context worked together from the perspective of the individual" (ibid: 58).

In his second case study, Chapman uses Cost Surface Analysis (CSA) alongside viewshed analysis, to explain the route followed by the Rudstone Cursus (Chapman 2003). To do this he assesses two contrasting hypotheses – (1) that the cursus simply follows the easiest route (requiring least physical effort) between the termini, and (2), that the route of the cursus is designed to enclose a sacred place of meaning, or *temenos*. The first hypothesis was addressed by creating a least cost path across the landscape, and the second, by creating a cumulative viewshed map from points along the actual cursus. The least cost path deviated significantly from the currently observed path of the monument, and thus its route cannot be explained in these simple functional terms. The viewshed data however indicated "a strong visual relationship" (ibid: 352) between the cursus and the Denby and Rudstone long barrows, which are skylined on the horizon to its west. This can be paralleled with observations at the Dorset cursus, whose route way references views to nine earlier Neolithic barrows. The monument could have acted as a processional route, linking places of already existing meaning and significance.

3.5.7 Orcadian Tombs

The well-documented and often spectacular chambered tombs of Orkney were the subject of Woodman's study (Woodman 2000). These tombs are often described as being deliberately sited in "prominent locations", but Woodman suggests these are general assertions based on qualitative and subjective fieldwork (e.g. Fraser 1983). In her analysis she seeks to address three main questions – (1) whether the tombs really are located in prominent locations, (2) whether there is any indication that views *from* monuments were more important than views *of* the monument, and (3), whether viewshed patterns were causal agents in determining site locations.

To assess her first question regarding prominence of location, Woodman compared the viewshed areas of the chambered tombs with those of a random sample of non-site locations. The "completeness" of viewshed from the chambered tombs was substantially greater than the random sample, and this was statistically significant ($p<0.01$). Woodman recognised the issue of reciprocity, or the differences between *views from* and *views to* a monument. Although "views from the monuments are often spectacular" (ibid: 95), they were not particularly visible within the landscape themselves, with 66% of the current Orcadian landscape ***not*** affording views of any tombs. From this Woodman concludes that it is the view ***from*** the monument that was more important, and that extensive views over the sea were of greater significance than those over land. Intervisibility between tombs was also greater than between the random sample, and that this was not just a product of viewshed size – often those that were intervisible with two or three other tombs had smaller viewsheds than those intervisible with only one tomb, or none at all. This observation, along with the fact that even seemingly "inland" tombs were also located within sight of water led Woodman to suggest that visibility was an important causal factor in choice of monument location, but also importantly, not necessarily the only factor, with proximity to the coast also being significant.

3.5.8 Stonehenge Landscapes

Sally Exon, with her interdisciplinary team of archaeologists and IT specialists, conducted an in depth analysis of the monuments in a 10x11km block around Stonehenge "to explore, within a digital environment, the spatial relationship between monuments; to ascertain the reasoning behind the placement of monuments and to explore how these relationships changed over time" (Exon et al 2000: 4). Using a combination of viewshed analysis and field observations, the interspersing of the results of GIS analysis with excerpts from audio field records presents the reader with an account that feels more narrative than quantitative.

Their study of the Early Neolithic focuses largely on the distribution of Long Barrows in the study area. These barrows were quite variable, both in terms of size, and also size of viewshed. The larger viewsheds include Ell Barrow and Knighton Barrow, and enclose many other Long Barrows. Knighton Barrow has the largest viewshed, which *may* have extended as far as Knap

Hill. Examples of barrows with smaller viewsheds were Tilshead Lodge, and Normanton Down. Many barrows appeared to fall into a series of small clusters, often located at the tops of dry valley systems, or on the River Avon, as at Amesbury. These clusters, whose members are largely intervisible with each other, seemed to create quite an intimate sense of encounter, with those at Tilshead Lodge giving "a strong impression of a quiet closed-in atmosphere", and at Wilsford Down, around the Wilsford Shaft, "this tight little group of long barrows was encircling an area which must have been of great importance" (ibid: 40). The three main clusters are also visually linked to the Amesbury 42 and Winterbourne Stoke Down barrows. Interestingly, the line of sight between these latter barrows is also aligned along the Stonehenge Cursus, although this may have not been realised until the vegetation was cleared in the Middle or Later Neolithic – contemporary with the cursus.

Moving into the Middle and Later Neolithic, their description of the greater proliferation of monuments, including the henges, is rich and detailed. Stonehenge itself, along with Durrington Walls, seem to have quite small viewsheds, and are notably almost completely mutually exclusive, except around the very prominent Beacon Hill. Woodhenge and the Cuckoo Stone seemed to be deliberately sited in reference to earlier Neolithic barrows. Some Cost Surface Analysis is presented, and contradicts the notion that the route of the Stonehenge Avenue follows that of least effort. Visibility was calculated along the actual route of the Avenue, and can be viewed interactively on the accompanying CD-ROM, along with many other visualisations, and comprehensive set of viewshed maps for the study.

Just as important to this study as the results of their analysis, the authors have also provided alternative ways of displaying viewshed data to the default map perspective. Using a combination of approaches, including the use of Panoramic Virtual Reality as in this study, they have provided a more embodied means of interacting with viewshed data. This is discussed further in Chapters 5,6,7 and 8.

3.6 Chapter 3 Discussion and Conclusion

The use of GIS in archaeology has burgeoned since the publication of Interpreting Space. In European research, viewshed analysis has become widely adopted, as a means of escaping from the largely deterministic and processual school of Predictive Modelling. Still apparently popular in North American studies (Westcott and Brandon 2000), Predictive Modelling has recently been described by David Wheatley as being "essentially detached from contemporary theoretical archaeological concerns.... with significant unresolved methodological problems" (Wheatley 2004, Summary). Visibility studies themselves are not immune to methodological and theoretical problems, and rightly have not gone without due criticism, but it is argued here that as a sub-discipline, it has evolved from an earlier naivety to a post-critical stage of development. Many problems are now acknowledged and addressed, even if solutions have not yet been identified in all cases (ibid).

3.6.1 Methodological Advances

Several advances have been made improving the simple undifferentiated nature of binary viewsheds. These have included the use of gradient viewsheds (Llobera 1996), Higuchi and directional viewsheds (Wheatley and Gillings 2000), topographic prominence and visual exposure (Llobera 2001, 2003). Whilst all slightly different, they share in common their attempts to decompose the default binary viewshed into more meaningful components which give a more detailed description of the "visualscape" experienced at a given location. Largely initially proposed as methodological case studies, they are starting to find their way into recent literature, and are being linked directly to current archaeological theory (Trick 2004).

One of the most commonly cited methodological approaches to visibility studies has been Cumulative Viewshed Analysis (Wheatley 1995), particularly in studies of intervisibility. This is potentially a very powerful technique, allowing patterns of visibility from several monuments to be assessed and displayed simultaneously, readily identifying areas that fall within the view of one or more monuments. In its raw form however it is rather limited –

although it illustrates areas that can be seen from many points, it only indicates how many points, not which specific ones. There is a danger that in its raw form, some subtle relationships between specific sites can easily be masked. This both exacerbates and is exacerbated by the already present tendencies of simplification and reductionism in GIS studies, particularly in terms of monument typology and chronology. Whilst these analyses could be deconstructed by those with the sufficient motivation, access to the source data, and appropriate software facilities (inter-operability issues not withstanding), it is not very satisfactory for broader dissemination. A simple enhancement to this method is described and used in this study (see Chapter 4), which uses a simple arithmetic progression to reclassify individual viewshed layers before their cumulative Boolean addition. By using this approach, the resultant image is encoded with unique values, and from these it is possible to determine which monuments constitute the cumulative viewshed phenomena.

The likely impact of past vegetation on visibility in the landscape is still a thorny issue. Some attempts have been made to address these, with varying success. Tschan et al found that by elevating their DEM in certain locations by the appropriate height to reconstruct open woodland, they simply created an impenetrable barrier around their study site, totally curtailing visibility beyond its immediate location (Tschan et al 2000). This was a direct result of the raster data structure and their DEM resolution, as cell height cannot be adjusted in units of less than one whole cell. One solution would be to resample the DEM to a higher resolution, which would correspond more closely to the spacing of trees in open woodland e.g. 5 to 10 metres. Alternate cells could then be altered, creating some sense of permeability between them. Exon et al worked more qualitatively within a likely model of past vegetation around the Stonehenge environs, alerting the reader when appropriate that tree cover or scrubland could possibly distort patterns of visibility observed in the present (e.g. Exon et al 2000: 41-42). Recent releases of GIS software are starting to allow the incorporation of vegetation into their visualisation modules, but this is not incorporated into their analytical routines e.g. ESRI's ArcGIS 9. Certain visualisation packages also allow the manipulation of (specifically) tree cover, and offer seductively attractive, but ultimately totally subjective "embodied" views of the landscape.

Another trend in recent studies is the use of quantitative techniques, and without these phenomenological studies can seem a little idiosyncratic (Trick 2004). However a balanced view needs to be taken. Generally, quantitative analysis is performed to test against a Null Hypothesis, often by comparing viewsheds of known sites with those from randomly generated non-site locations, but the utility of this approach really depends upon the underlying archaeological questions being asked. Typically, this is the approach taken in studies of intervisibility (Fisher et al 1997, Joyce 1995, Roughley 2001, Wheatley 1995, Woodman 2000). Yet some of these studies still seem to exist in a theoretical vacuum – intervisibility is tested and either "proved" or "disproved", but rarely in the literature is it made explicit why the question is significant, and what the results actually tell us. In the case of the well studied and discussed Peak District, it might be argued that intervisibility between Neolithic tombs indicates some level of social connectivity between the groups that built and used them – possibly via lineage, or shared and fluid tenure over the land. In the latter case, we may be more interested in the actual land shared between them, the land in view from 2 or more barrows, not the intervisibility of the monuments themselves. Traditional Cumulative Viewshed Analysis only tells us that "land is shared", not by whom.

Joyce determined that intervisibility between Neolithic tombs in the Peak District was not statistically greater than in a random sample, and concluded that the viewshed patterns observed were simply a product of topography. Topography is obviously the one environmental factor that has the single greatest effect on a viewshed, but to conduct a statistical analysis and conclude simply that, is selling the data short. When too much weight is placed on quantification in this way, then viewsheds truly "can be used in lieu of thinking about a problem" (Aldenderfer 1996: 16). The existence of excellent tools such as Mark Lake's *r.cva* module (Lake et al 1998) may draw us further down this path. There is a danger that because CVA can be automated, it routinely is. With most of the attention being placed at the *p* value returned at the end, too little is focused on heuristically examining the intermediary data – i.e. the individual viewsheds and their various stages of recombination.

So there seems to be something of an anachronism at work here. Viewshed analysis rose in popularity to escape from the processual and deterministic archaeology of the 1970s and 80s – in other words, to try and *humanise* GIS studies, and enable a more reflexive and phenomenological approach consistent with current archaeological thought. By allowing "quantitative rigour" to dominate our interpretations of this data, we may be in danger of simply de-humanising it again. As Stanton Green commented over 15 years ago "by reducing space to a statistic it loses its descriptive force" (Green 1990a: 4).

3.6.2 Theoretical Advances

Much progress has been made from the earlier functionalistic applications of viewshed analysis (e.g. Krist and Brown 1994, Gaffney and Stancic 1991) to the kinds of discussions being offered by contemporary authors. There is now broad consensus that for any GIS based studies to be meaningful, they need to be theoretically situated and driven by relevant archaeological questions.

Quite a lot of debate has focused around the nature of human perception, and how satisfactorily viewshed analysis enables us to reconstruct this in the past. The shortcomings of the map perspective, and the primacy of vision are now quite well rehearsed. GIS studies are not the only offenders in presenting archaeological data in the disembodied format of the map, with more conventional distribution maps, and even the familiar archaeological convention of the plan being equally guilty (Barrett 1994, Thomas 1993). The problem of representing phenomenological data has been acknowledged in more conventional landscape studies, and is not confined to users of GIS (Cummings et al 2002). Multimedia technologies are increasingly being employed as a means of moving beyond this, to enable a more interactive and subjective landscape experience (e.g. Cummings 2000a, 2000b, Exon et al 2000, Larkman 2000, Roughley 2004, Roughley and Shell 2004, Trick 2004). These are addressed in more depth in Chapter 5,6 and 7. Critics of visualism have called for more multi-sensory approaches to past perception that can incorporate sound, smell, taste and touch (Gillings and Goodrick 1996). So far this has remained largely un-addressed, although some progress has been achieved in the incorporation of sound into GIS representations (Mlekuz 2004) and virtual reconstructions (Mills 2000, Pope and Chalmers 2000). Despite all the problems associate with visualism, vision still seems to be central in current phenomenological studies (Brück 2005, Thomas 2006 c.f. Cummings 1999, 2000, 2002, Cummings et al 2002, Cummings and Whittle 2003, Fleming 1999, 2005, Thomas 1993, Tilley 1994).

Recent authors are now pursuing fruitful avenues of research by seeking to interpret their viewshed data within a well-situated theoretical perspective. Visibility and other GIS based studies can now be seen to address contemporary issues such as Bourdieu's concept of *habitus*, Heideggerian dwelling, Barrett's work on agency, and Foucault's ideas on vision, surveillance and control (Llobera 1996, Trick 2004, Van Hove 2004, Rajala 2004 respectively), and now sits within a clearly defined epistemology and ontology, in which its results can be interpreted from pragmatic and realistic perspectives (Rajala 2004). Ascribing meaning to viewsheds is not unproblematic, and is a separate issue from the analysis of perception itself (Rajala 2004). Although the permanence of landscape features allows us to reconstruct past perception in the present, there are dangers in assuming a universality of this perception (Brück 1998, 2005). The significance of viewshed from any given location does not exist *a priori* (c.f. van Leusen 2002), but has to be established prior to any analysis for results to be meaningful – i.e. it needs to be determined outside of the analysis, and be based on current theoretical and archaeological questions. Although some authors are prepared to explore direct links between viewshed data and current archaeological theories, others are more cautious. For Gary Lock, viewshed analysis is unlikely to ever meaningfully represent a sense of "place", as such meaning resides in people, not the landscape itself (Lock

2000, 2003). Exon has her own reservations about these studies' attempts to engage with contemporary theory, stating that "even with the provision of an attached theoretical justification (c.f. Llobera 1996: 613-6), they remain at best only spatially insightful" and that they "do not represent a radical re-positioning of spatial studies in relation to contemporary discourse" (Exon et al 2000: 13).

Even more elusive and harder to define, is whether visibility to and/or from given sites was ever causal in choosing their locations. In Fraser's non-GIS based study of viewsheds from tombs in Orkney, the importance of visibility was "unequivocal" (Woodman 2000). Other authors advise caution (e.g. Wheatley 1996, Roughley 2001, 2004, Chapman 2003), suggesting that other factors may have been equally important.

As a single line of enquiry, GIS studies are not sufficient, but are valid within more holistic approaches to landscape including the more "traditional" methods of ground-truthing, survey and excavation. Arguably it is only within the context of these broader studies that it will be possible to realise the oft-cited need for "an embedded, theoretically and archaeologically informed GIS" (Wheatley and Gillings 2002: 237). Although this chapter has demonstrated that GIS based studies have their problems, their limitations maybe based as much in current archaeological practice as they are in GIS methodology (Rajala 2004). As David Wheatley says "pointing out that visibility analysis is not complete is not the same as arguing it is inherently defective" and that "not only can visibility analysis claim to be significantly rooted in recent intellectual debates within archaeology and related disciplines, but it can also point to methodological developments and archaeological results that set it apart as the most promising area of application for GIS technologies" (Wheatley 2004: 4). The driving force behind advances in archaeological GIS research are no longer ones of technology and practice, although progress has been made here, but are now those questions addressing theory, epistemology, and knowledge creation using GIS.

Viewshed data, even in its current crude form, is valuable. In the cases of those who study remote locations, it may be all they have. Synergies with other new technologies offer the potential to provide more embodied representation of viewshed data (Exon et al 2000, Roughley 2004, Trick 2004). The time has come to take viewshed analysis Beyond the Map....

Chapter 4 - Viewshed Analysis of Neolithic Monuments of the White Peak

4.1 Introduction

The primary aim of this chapter is to explore how GIS based viewshed analysis can enhance our understanding of the distribution of Neolithic monuments across the landscape of the White Peak. In doing so, this Chapter primarily addresses the first of the main aims of the thesis as outlined in 1.4, which is to resolve the human experience of monuments and landscape over a regional scale of spatial resolution, using GIS based viewshed analysis.

The study of mortuary structures has played a very important role in shaping views of the Neolithic throughout archaeology's existence as a discipline, and funerary evidence for the period is far more extensive than for settlement or subsistence (Pollard 1997, 1999, Thomas 1999). This is as true for the Peak District as it is in any other part of Britain (Barnatt 1996a).

Anthropological studies suggest that the way the dead are treated can tell us a lot about the beliefs of the living (Huntingdon and Metcalfe 1991), and that the location of the dead within the landscape is of great social and cultural significance (Parker Pearson 2003). By drawing on ethnographic analogies, the location of the mortuary practices may suggest how other activities may have been distributed in the landscape (Thomas 1999, Parker Pearson 2003). The creation of these new architectural forms represents a radical departure in social activities from anything witnessed archaeologically from the Mesolithic or Palaeolithic (Bradley 1993).

Monuments create a new sense of "place" within the landscape that is also durable, thus fostering a sense of timelessness and memory (Bradley 1993). The architectural form of monuments can also structure proceedings in the rituals that took place there, and so can actually shape the nature of human experience (Barrett 1994, Fleming 1973). Burial monuments specifically can hold the remains of the dead, but can also hold those of the "ancestors", whose presence in conjunction with ritual can anchor people to the landscape, and help legitimise claims of tenure and access (Barnatt 1996, Barrett 1994, Edmonds 1999a, Tilley 1994). These are key themes that have been developed extensively by several contemporary authors, and they provide the interpretative framework for this analysis.

4.2 – General Description of Neolithic Tombs

There are several hundred examples of Neolithic tombs distributed throughout Britain (Pollard 1997), and although there is significant variation throughout, they are typologically divided into two main groups.

4.2.1 – General Typology

Earthen long barrows are typically comprised of a rectangular mound of 15 to 125m in length. Examples that have seen modern excavations often appear to start off as timber mortuary enclosures, which after the interment of human remains within, are covered over by mounds comprised of various raw materials, e.g. Haddenham, Nutbane (Barrett 1988, 1994, Kinnes 1992, Thomas 1999). By contrast, megalithic chambered tombs are typically comprised of one or more substantial stone chambers, again covered over by a mound. These chambers might be set laterally in the mound, each one facing outwards e.g. Hazleton North (Thomas 1999), or may have a passage acting as an entrance in the end of the mound to one or more chambers within, e.g. West Kennet (ibid). This latter group are often called passage graves.

Both of these forms are prevalent during the earlier and middle parts of the Neolithic, between the 4th and 3rd millennia BC, and there is no clear chronological sequence between the two. During the later Neolithic, some of these monuments become embellished in size, with access to any human remains within being blocked. In some cases, structures are elaborated on the outside of the tomb, in the forms of facades or forecourts (Barrett 1988, Bradley 1984, Edmonds 1999a,Thomas 1999). A third, slightly anomalous type exists in the form of bank barrows, which are of considerable length. Notable examples of this type are within the enclosures at Maiden Castle and Crickley Hill (Thomas 1999).

4.2.2 – Peak District Typology

As introduced in Chapter 3, there are thirteen definite examples of Neolithic tombs in the Peak District, although this number can be nearly doubled if *possible* examples are included (Barnatt and Collis 1996, Barnatt 1996a). All of these monuments are located in the White Peak, which is the geographical heartland of the region. These have been categorised by Barnatt as simple closed chambered types, long barrows, and passage graves. These are shown in Table 4.1 below.

Excavations at Minninglow (Marsden 1977) suggest a possible chronology, starting with simple closed chambers, followed by long barrows, with passage graves *possibly* being the latest of these three types. Although the chronology is useful, it should be treated with caution as it is based on quite limited evidence (Barnatt 1996a). As in other parts of the country, seven of these earlier monuments were embellished in size to become "Great Barrows" (after Manby 1958), including a somewhat atypical bank barrow at Long Low (Barnatt and Collis 1996).

Name	Type
Long Low	CC
Ringham Low	CC
Stoney Low	CC
Tideslow	CC
Bole Hill	CC?
Bostern	CC?
Minninglow	CC?
Pea Low	CC?
Smerril Moor	CC?
Stanshope	CC?
Wardlow	CC?
Wind Low	CC?
Gib Hill	LB
Harrod Low	LB
Long Low	LB
Longstone Moor	LB
Perryfoot	LB
Rockhurst	LB
Bull Ring	LB?
Gospel Hillocks	LB?
One Ash	LB?
Ringham Low	LB?
The Tong	LB?
Five Wells	PG
Minninglow	PG
Green Low	PG
Harborough Rocks	PG
Pea Low	PG?
Stoney Low	PG?

Table 4.1 - Neolithic burial mounds in this study. CC – Closed Chamber, CC? – possible Closed Chamber, LB – Long Barrow, LB? – possible Long Barrow, PG – Passage Grave, PG? – possible Passage Grave.

4.3 - Burial Monuments – From Economy to Phenomenology

Before embarking on the viewshed analysis of the Neolithic burial mounds of the Peak District, they need to be situated within the contemporary interpretative framework that has been established for thinking about these monuments over the last 30 years.

4.3.1 – Tombs and territories

The first real arguments that tombs had an important role within the wider landscape were put forward by Renfrew in 1973, looking at the distributions of burial mounds and causewayed enclosures in Neolithic Wessex. Renfrew took 120 barrows from this region, and following Ashbee's earlier allocation of these into five main groups, suggested that each one of these tombs served a "tribe" or extended kin group, acting as territorial markers defending their prime resource of good arable land. Based around a model of a sedentary arable Neolithic subsistence, Renfrew believed that the suggested labour requirements of 500 person days to construct a barrow like Fussell's Lodge could be mobilised in a single year, enabled by a stable surplus arable economy. These relatively modest projects were placed at the bottom of a hierarchy of monuments, with henges and large causewayed enclosures sitting at the top.

One problem with this model is that it is dependent on the assumed sedentary agricultural subsistence base with its associated surpluses of time and produce. Another problem is the idea that there were "territories" that needed delineating by tombs. Ethnographic evidence suggests that many traditional societies do not view land tenure in this way (Ingold 1986).

The third problem in Renfrew's thesis is the idea that their construction took place in a single episode. Where these monuments have been excavated under modern conditions, many appear to have long and complex sequences of construction far greater than the "slack" time available within a single farming year. Notable examples of these are Wayland's Smithy (Whittle 1991), Haddenham (Hodder and Shand 1988), Streethouse (Vyner 1984), and Nutbane (Morgan 1959). Often these have quite elaborate timber mortuary structures that predate the creation of the actual mound, and in some cases these may have been exposed for some time, e.g. Cold Kitchen Hill (Harding and Gingell 1986). Taken together, this evidence refutes Renfrew's suggestion that such structures were built within a single year.

4.3.2 Tombs for the Living

Andrew Fleming's landmark paper "Tombs for the Living", introduced a different perspective on how to look at tombs (1973). Fleming chose to explore avenues of enquiry that opened up the use of tombs by the living to a much broader repertoire of social meanings and in doing so set up many themes that have been developed extensively since. Treating the metrics of Renfrew's labour estimates with suspicion (from Atkinson 1956, Ashbee and Cornwall 1961), Fleming proposed longer durations of more intermittent building of particular tombs over time, and called for "more than one way of thinking about how tomb construction may have fitted into the pattern of activities" (Fleming 1973: 179).

Fleming suggested tombs would be used by the living as a means of maintaining the structure of society. For tombs to be significant amongst the living, they would need to be visible – both in terms of their architectural form, and also their landscape settings (Fleming 1973). Ethnographic evidence suggests that the placing of the dead in the landscape is not a random affair, but instead "will have significant and powerful connotations within people's perceived social geographies" (Parker Pearson 2003: 141). Through the placing of the dead, the landscape becomes inscribed with meaning (ibid). In other cases, tombs may have been placed at locales that had significance stretching into the deep past (Bradley 1993).

Tombs were likely to perform important functions for the living over and above being mere containers for the dead (Fleming 1973). Ritual activities performed at tombs could be used to maintain and/or change existing social structures of cohesion and leadership, and in particular where claims to power or tenure "were based on a relationship with the dead enshrined in the tomb" (ibid: 189). Tombs may also have been placed in prominent locations so that they were visible throughout the year (ibid).

4.3.3 – Ancestors in the Landscape

Many Neolithic tombs contained multiple burials, often de-fleshed and disarticulated prior to interment (Barrett 1988, Thomas 1999). As de-fleshed bones, these human remains could act as powerful sources of symbolism, with their durability representing some kind of more abstracted absolute, such as the presence of the spirits of the ancestors. This has been noted in ethnographic evidence, where the bones of the dead have been specifically sited in the landscape to allow access to this ancestral presence. In such societies, the transition from the fleshed body of the recently dead, to the de-fleshed bones of an ancestor, may be seen as "dangerous and polluting" (Pollard, 1997: 52), requiring a period of liminality wherein the corpse may be taken elsewhere to facilitate this transformation. Causewayed enclosures have been suggested as a possible venue for this process in the South West of Britain (Edmonds 1993). The importance of these remains as potent symbols of ancestry was made explicit by Shanks and Tilley (1982), who interpreted such disarticulation and deposition of the dead as an intentional denial of the identity of any one individual, instead being subsumed into the corporate identity of the anonymous ancestors, so to watch over the fate of the living.

Evidence for how these potent symbols of ancestry can be deployed amongst the living can be seen with chambered tombs. Although there is evidence that the remains of the ancestors were accessible within mortuary structures prior to the raising of earthen long barrows, this is further exemplified in the case of chambered tombs, wherein this is access is enabled by a commitment to the architecture of stone. In some larger bone assemblages, uneven representations of body parts has led to the interpretation that ancestral remains were removed from the tombs and were circulated amongst the living, as at Hazleton North, where skulls and long bones were "missing" (Saville 1984). It has also been suggested that there may have been reciprocal traffic of bones between monuments. This could have symbolised the ultimate act of negotiation, where bones from the ancestors of one group were transported and deposited in the ancestral homes of another.

Excavators at Hazleton North reported an arrangement of slabs that would facilitate a removable blocking device, put in place between episodes of bone deposition or removal (ibid).

Although considerable variation exists between different cases, there are *many* ethnographic examples where the spirits of the ancestors exert power over the fate of the living. This can include fertility, success in hunting or cultivation, and also in asserting tenure over the landscape (Bloch and Parry 1982, Huntingdon and Metcalfe 1991, Parker Pearson 2003, Tilley 1994). Tombs provide a fixed point of presence for the ancestors spatially, by anchoring them to a certain point in the landscape. They also do so temporally – their long durations of use stretching over many human generations, and outliving any one individual, would bring those from the distant past into the present (Bradley 1993). Some authors would stress the importance of fixing the ancestors to points in the landscape close to pathways or locales whose significance stretch back to the Mesolithic (Barnatt 1996a, Edmonds 1999a, Tilley 1994). Importantly, monuments such as tombs both "*objectified* ancestral powers in the landscape", and demonstrated "a will to make ancestral powers in the land *visible*" (Tilley 1994: 204, emphasis original).

4.4 - Neolithic Tombs in the Peak District – Current Models

The typologies of these tombs has been summarised in 4.2.2, and Table 4.1 above. The largely scant excavation evidence for these has been meticulously detailed in Barnatt and Collis's excellent corpus (1996)

In terms of landscape setting, Barnatt refutes the relevance of Tilley's arguments regarding the careful association of monument siting with prominent natural features, suggesting that it is not apparent with the Neolithic burial mounds in the Peak District (1996a). There are other potential explanations to examine. Firstly, the monuments don't need to visually resemble any nearby natural features in order for them to reference them. Secondly, their locations probably have more to do with associations with past activities. Many Early Neolithic burial mounds in the Peak District and in the rest of Britain can be seen to overlie evidence for Mesolithic activity, whether in the form of prepared ground surfaces, or from artefactual evidence (Barnatt 1996a, Barrett 1988, 1984, Bradley 1984, Edmonds 1999a, Thomas 1999). Very clear evidence for this has been demonstrated at Whitwell Long Cairn, near Creswell Crags, a mere 20 km to the south of the region (Edmonds and Seaborne 2001). Equally recently, surface survey data from fields around the Early Neolithic Gib Hill long mound have shown a complex palimpsest of activity ranging from the Later Mesolithic to the Bronze Age (Hind 2000, 2004). Excavations at Green Low by Manby (1965) showed that this passage grave sealed a deposit containing Mesolithic material, and Bateman's excavations at Gib Hill revealed that appeared to be a prepared clay surface. Much Mesolithic material was also recovered from around the now destroyed but certain passage grave at Harborough Rocks – a striking natural feature likely to have significance stretching back in time prior to the Neolithic (Edmonds and Seaborne 2001). Thirdly, their siting and orientation may in some cases relate to astronomical alignments at key times of the year.

Fourthly, their siting may have been strongly influenced by the visibility of certain locations, including other monuments. Being highly visible in the landscape may have been important if these monuments were partly intended to act as a constant reminder of the presence of the ancestors, as suggested above. Conversely, it might be equally important that these monuments not by highly visible from a broad area, and that visiting these could be designed to entail complex and subtle moments of revelation in the negotiation of the landscape. The importance of what can be seen from any monument also has many facets. For various reasons unknown to us, it could have been important the certain monuments could be seen from other monuments. It could be equally important that they might be hidden. The ability to see natural features, such as sources of stone or watersheds, as well as the grazing land over whose tenure they were designed to assert, may also have been important (Barnatt 1996a, Edmonds 1999a).

In the absence of any available viewshed data for these monuments, Barnatt concluded that there was no strong pattern of distribution for the earlier monuments, although the long barrow types are more prevalent in the northern half of the region, as are passage graves in the southern half (1996a). The closed chamber type a relatively evenly distributed from north to south. Barnatt has also argued that Later Neolithic barrows are all quite close to the boundaries of watersheds, although this is not clearly defined (ibid). This could just be an artefact of their topographical setting, as these monuments tend to overlook upper river basin pastures. He also suggests that it is along these watershed boundaries that people would travel throughout the seasonal round, and here they would be more likely to encounter others, and therefore more likely they would need to have recourse to reaffirming their ancestral tenure over these upper grazing areas. This is further echoed by Edmonds and Seaborne (2001).

During the Later Neolithic, seven of the earlier monuments become embellished in the manner discussed in 4.2.1. above, described by Barnatt as the "Great Barrows". Barnatt sees these Great Barrows and the two henges as comprising groups of "monument complexes", which he aggregates into five main regional groups, summarised in Table 4.2 below:

Location	**Monuments in complex**
North West	Bull Ring henge
North East	Tideslow great barrow
Central	Arbor Low henge, Ringham Low and Bole Hill great barrows
South West	Long Low bank barrow, Pea Low great barrow
South East	Mininglow and Stoney Low great barrows

Table 4.2 – Geographical location of later Neolithic monuments in this study.

Barnatt again comments on their location in the landscape, stating that, "It is hard to dismiss the repetitive spacing between these five monument groups as coincidence, as it contrasts with the distributions that went before and because similar patterns recur over large parts of Britain" (1996a: 52). Barnatt invites us to consider these monuments within each complex as being connected by well established pathways or routes, to which he attributes a sacred status. As these monuments were required to accommodate more participants over time, their need to be in prominent locations would have become more apparent, and this could have been a major driving factor behind choosing which monuments became embellished, and which fell out of use.

4.5 –Viewshed analysis

4.5.1 – Introduction and Methodology

Previous models of the Neolithic in the Peak have been discredited due to their use of environmentally deterministic approaches (Chapter 2, Barnatt 1996a, Hind 2000, Edmonds and Seaborne 2001 c.f., Bradley and Hart 1983, Hawke-Smith 1979). Similarly, early uncritical uses of GIS analysis have been discredited on the same bases (see 2.3). Because of this, viewshed analysis has been adopted in this study.

Although not without its own methodological and theoretical problems, this approach at very least enables some sense of how these tombs would have been perceived in the past. Visibility from tombs may be significant for several reasons. Firstly, the land from which tombs are visible would be significant to those carrying out the daily routines of life, and in these zones the ancestors could be seen to watch over the actions of the living, bringing "the presence of the ancestral past into consciousness" (Tilley 1994: 202). Secondly, land that can be viewed from a given tomb would be of significance to those visiting and attending rituals at these monuments, and this viewshed *may* represent land held in tenure by any given group. It should be noted that this is by ethnographic analogy alone. Following from this, areas of land in view from several monuments could be subject to more fluid negotiation of tenure by groups visiting upland pasture zones. This has been implied in other studies where CVA techniques have been applied (e.g. Wheatley 1995).

Individual viewsheds for the monuments have been created using the standard Calculate Viewshed procedure provided in the ESRI ArcView 3.2 Spatial Analyst module. The viewsheds were calculated using the default observer height of 1 metre. The implications of this are discussed in the Conclusion section below.

Two forms of Cumulative Viewshed Analysis have been performed using the individual viewsheds created above. The first of these will be referred to in the text as the "standard CVA", in which the simple binary viewsheds from each monument considered are added using basic map algebra. The numerical value for any point in the resulting image represents the number of monuments whose viewshed encompasses that point (Wheatley 1995). The "2-series CVA" is a minor methodological refinement to this method. In this method, each monument's individual viewshed is reclassified in a numerical sequence based around increasing powers of two (S. Wise, *pers comm*). When these viewsheds are summed using map algebra, the resultant image contains unique values, and from these it is possible to determine which particular monuments contribute to the cumulative viewsheds observed.

This 2-series CVA approach can be simply demonstrated in the case of figure 4.13. In this example, the Tideslow viewshed remains coded as "1", and the Minninglow viewshed has been reclassified to "2". When these are summed, those areas coded with the number "3" are the zones of intervisibility. The individual viewsheds of both are still resolvable, as they retain their constituent codes.

4.5.2 - Specific Questions Regarding Neolithic Monument Location in the White Peak

Following on from the recent models of Barnatt (1996a, 1996b), and Edmonds and Seaborne (2001), outlined in sections 2.3.3 and 2.3.4, exploratory viewshed analysis may enable the following questions to be addressed:

Firstly the analysis may enable a general assessment of the location of the monuments in terms of topography and hydrology. In particular the analysis may enable an assessment of whether the Neolithic tombs overlook upland grazing areas, which would have been utilised as part of the seasonal round.

Secondly the analysis may enable a chronological interpretation of the location of the monuments. Following the putative chronology for tomb typology proposed by Barnatt (1996a), it may be possible to determine whether there is an observable change in the scale of viewsheds from the local, in the case of the earlier monuments (Closed Chamber and Long Barrow types) to the more regional, in the case of the later Passage Graves and Great Barrows. In the case of the Passage Graves, it may be possible to determine whether these monuments have larger viewsheds than earlier monuments. In the case of the Great Barrows, it may be possible to determine whether the viewsheds from these effectively encapsulate the viewsheds from the earlier monument types. Finally, it may also be possible to assess the relationship between the location and viewsheds for the Later Neolithic henge monuments (Arbor Low and Bull Ring), and the Later Neolithic burial mounds.

Thirdly the analysis may enable a non-chronological interpretation of the monuments' location. This may include a spatial interpretation of the monuments' location, and in particular, an assessment of Barnatt's regional groupings for the Later Neolithic Great Barrows and Henges.

Finally, by performing a rudimentary hydrological analysis of the region, it may be possible to assess Barnatt's suggestion that the Great Barrow's and Henges tend to occur near watershed boundaries.

In addressing these questions, the location and viewsheds of the monuments may be assessed in terms of their relationships to the location and viewsheds of other monuments, as well as the physical landscape.

4.6 – Results of the Analysis

The viewshed evidence will firstly be presented by type, in accordance with Barnatt's proposed chronology, treating the Closed Chamber type as the earliest, progressing through to Long Barrows and Passage Graves, and finally, the Great Barrows and Henge monuments of the Late Neolithic. The analysis will also be discussed in terms of the regional schema proposed by Barnatt, summarised in table 4.2 above.

4.6.1 - Closed Chambers

The monuments examined in this category are the certain examples of Long Low, Ringham Low, Stoney Low and Tideslow; and in addition Bole Hill, Minninglow, and Pea Low. As discussed above, these latter monuments (all Great Barrows) have long constructional sequences, which often appear to incorporate aspects of different types, although unfortunately it is very often this clarity of evidence that has been destroyed by Antiquarians and tomb raiders.

Figure 4.1 shows the physical size (area) of the viewsheds generated for each monument in the group, and the considerable degree of variation in the extent of these viewsheds is quite obvious. At the lower end, the Ringham Low, Long Low, Stoney Low and Pea Low viewsheds range from 10 to 25,000 m^2, whereas Bole Hill, Tideslow and Minninglow have viewsheds of 88, 105 and 146,000 m^2 respectively. Although the barrows with the smaller viewsheds are at lower altitudes than those with the larger, they are all still located on the limestone uplands, rather than valley sides; and the correlation between height and viewshed area of each monument, (shown on Figure 4.2) is not a simple linear one. In the first instance then, it appears that not all the barrows have been sited to maximise the area of their viewsheds.

The location and extent of these monuments' viewsheds is shown on Figure 4.3, and again the nature of these is quite heterogeneous. As a rule, the larger viewsheds extend over greater linear distances away from their respective monuments than do the smaller ones (i.e. they can see more land at a greater distance away than the smaller ones), but this is not an absolute rule. The nature of some examples of these is discussed below.

Ringham Low provides good example of a small viewshed, which is also confined to within a relatively short distance of the monument itself. This barrow is situated just to the north of the top of Lathkill Dale, and the vast majority of its viewshed occupies a contiguous "corridor" running north west for seven kilometres from here, although this corridor itself lies on land to the south of this natural feature, as shown on Figure 4.4. Long Low, Pea Low and Stoney Low have viewsheds which are similarly local in view, but these also contain small parcels of land that are very far away with Kinder Scout being *theoretically* visible in the cases of Long Low and Pea Low.

The viewshed is very different in the case of the Tideslow Great Barrow, shown in Figure 4.5. The view from this monument is both large and panoramic, not being largely confined to a single direction c.f. Ringham Low (see Figure 4.4). The viewshed encompasses Tideswell Moor to the immediate north, much of Longstone Moor to the near south-east, the land south of the River Wye at Miller's Dale down towards Taddington, land just south of Bakewell, the upland areas at the top of Cale Dale (the southern top of Lathkill Dale), and as far south as the land around Minninglow between Elton and Ballidon. In most cases this land lies directly above (altitudinally) the tops of many dales and dry valleys, even at some distance from the monument itself. People travelling south out of much of the Wye valley, up into the Limestone along these gorges, would encounter one of these viewshed zones within a few miles, almost irrespective of where they chose to

leave the shelter of the valley and enter the upland grazing areas. Travellers entering the limestone uplands from anywhere between Grindleford and Baslow (and there are many Dales which will take you up), will quite quickly find themselves in ancestral lands, as they cross over Longstone Moor, soon encountering the viewsheds of Minninglow, Bole Hill, and monuments of other types. The overall character of this viewshed is echoed by Minninglow and Bole Hill, although they largely address other locations.
Looking at the intervisibility of these monuments enables suggestions can be made about the relationships between them. The area to the south-west of the limestone, with the Long Low, Pea Low barrows (with nearby possibles, Stanshope, and Bostern), again provides an interesting example. Long Low and Pea Low are intervisible, with each one sitting in a very restricted viewshed of its own, but at the edge of a more extensive tract of land viewed from the other. This can be visualised more clearly than explained, as depicted in Figures 4.6 and 4.7. Figure 4.8 shows the overlap between these two, where the land is in view from both. The Stanshope barrow is in view from Pea Low, but not Long Low, although considerably nearer to the latter. The Bostern barrow is also visible from Long Low, Pea Low and Minninglow, again sitting on the very edge of the viewsheds of each. All four barrows create a complex pattern of intervisible land overlooking upland areas between the Rivers Manifold and Dove, near Alstonfield and Wetton. Similar subtle patterns of intervisibility can be seen between Minninglow and Stoney Low; and Ringham Low and Bole Hill.

There are many other examples in this group alone where barrows fall either just within or outside of the viewsheds of other barrows, but at more substantial distances away. Tideslow for example has Windlow, Five Wells, Bole Hill, Minninglow, Stoney Low (just outside), Rockhurst and Longstone Moor at its margins, the latter two of these being Long Barrows. The point-to-point visibility of the Closed Chamber group is shown in Figure 4.10.

Using Cumulative Viewshed Analysis (CVA), it is possible to make assessments about the articulation of land between the monuments, and as such makes the landscape itself the unit of analysis, rather than the

monuments *per se*. The Simple CVA provides a fairly crude indication of where land can be viewed from multiple monuments, but only tells us how many, not which actual ones. The simple CVA for this group is shown on Figure 4.11, and superficially indicates that much of the land in view is only viewed from one monument, and that generally, areas of overlap are small. One notable exception to this is a substantial area of land immediately south of Longstone Edge, which is visible from two barrows
Using the 2 Series CVA it is possible to determine which barrows are responsible for areas of overlapping viewsheds. The disadvantage with the approach is that it rapidly creates data sets that are too complex to readily understand. For this reason the 2 Series CVA maps presented here have been simplified so as to only display the overlap zones, as shown on Figure 4.12. This shows that the large tract of "shared" land immediately south of Longstone Edge, with a view code of 80, is in view of both Minninglow and Bole Hill. More striking "hotspots" of intervisibility occur around Stanton Moor, Minninglow, Bole Hill, Kinder Scout to the far north, and the gritstone edges of the Eastern Moors. In the land immediately surrounding the Bole Hill barrow, there is a complex series of intervisible zones, created by various combinations of the viewsheds from Minninglow, Tideslow, Ringham Low, and Bole Hill itself.

One striking combination of viewsheds that is impossible to ignore is that of Minninglow and Tideslow. Both have very large viewsheds, but are almost completely opposing, with very little land held in view by both. Taken both together they create a very apparent "north-south divide", with sharp but abutting boundaries running between the Five Wells and Bole Hill barrows in the central zone of the White Peak, but also along Longstone Edge, effectively dividing Longstone Moor into two halves. This boundary is again very clearly depicted by the 2 Series CVA, on Figure 4.13. The relationship between these two barrows is discussed in further detail in section 4.4.3.4 below.

4.6.2 – Long Barrows

The definite examples of Long Barrows considered in this category are Gib Hill, Harrod Low, Long Low, Longstone Moor, Perryfoot, and Rockhurst. Of these, Long Low is of a somewhat atypical "bank barrow" type. The physical area of these viewsheds is shown on Figure 4.14. As with the Closed Chamber group, there is some heterogeneity in the sizes of viewsheds for this group, although it is less pronounced than in the above category. The smaller viewsheds are similar in size to those in the previous group, belonging to Harrod Low, Perryfoot, and Long Low. Of the larger viewsheds, only Rockhurst is comparable with Bole Hill, Tideslow and Minninglow, with a viewshed of 109,000m^2; with Gib Hill, and Longstone Moor having viewshed areas of 51,000m^2 and 49,000m^2 respectively. Interestingly, none of these definite examples appear to have become Great Barrows, apart from the atypical Long Low. As with the Closed Chamber group, at appears on first inspection that these monuments have not all necessarily been sited to maximise their viewsheds.

The individual viewsheds for this group are depicted on Figure 4.15. As with the Closed Chamber group, there is also some degree of heterogeneity in their character. The Perryfoot and Harrod Low barrows are interesting examples of the smaller viewsheds. These two barrows are the northern most of all the Neolithic monuments in this study, both sitting at the northern end of the complex of dales that run due north from the River Wye at Monks Dale, and their viewsheds are shown on Figures 4.16 and 4.17 respectively. The viewsheds of both barrows are quite "patchy" here, seemingly comprised of quite a few small and discontinuous parcels of visible land running down the upland sides of this complex of Dales. Both barrows incorporate views both of the Dale/valley sides, as well as the upland areas lying above, and *generally* address the opposing side of the valley feature from their own location. On superficial examination, these parcels of viewed land appear to follow the lines of stream beds, and this will be re-examined in the light of the hydrological analysis presented in Section 4.7.1.

Longstone Moor, approximately 10 km to the east-south-east of these, has quite a contrasting viewshed (Figure 4.17a). Sitting in a very small (100 m^2) island of its own viewshed, much of the slightly lower ground within a radius of several hundred metres is out of view. Instead, the majority of its viewshed lies to the north, covering a fairly continuous tract of land running east-west from Eyam to Tideswell, and delineated to the north-east by Eyam Edge, but in the north-west continuing towards Bradwell and Castleton. It also has clear views of Froggatt Edge to the east and the upland shelves beyond.

The point-to-point visibility for this group is shown on Figure 4.18, and again shows some interesting relationships. Returning to Harrod Low and Perry foot, neither is intervisible with each other, but the Tong is visible from both, as are Five Wells and Harborough Rocks. Windlow lies just outside the viewshed of both Harrod Low and Perryfoot, whereas Bole Hill and Green Low lie just outside the viewshed of Harrod Low, at its central and southern margins respectively. Similar phenomena can be seen with other barrows in this group – at the central part of the limestone, Gib Hill's viewshed looks north west down Long Dale towards Elton Common, and the elevated land either side of this feature on Smerril and Grattan Moor, near Pikehall. This viewshed includes Minninglow, Rockhurst and Harborough Rocks, but just avoids Stoney Low, Green Low, and Bole Hill.

Figure 4.19 shows the Cumulative Viewshed Analysis results for the Harrod Low and Perryfoot Barrows, draped over the Peak DTM in orthographic view. This clearly shows that whilst they are not visible from each other, and are seemingly located having opposing views of the valley feature north of Monks Dale, both monuments together form a shared and complementary pattern of intervisibility over much of the land overlooking this feature, and that this viewshed follows the micro topography of the smaller stream beds radiating out from this feature. Maybe people get as far as the Tong, which can see both, and radiate from here along to more private pastures. Longstone Moor, whose viewshed seems to abut this combined viewshed of Harrod Low and Perryfoot, shares this part of this boundary viewshed with the Rockhurst barrow. The CVA shows a very sharp boundary between the Harrod Low and

Perryfoot viewsheds on one hand, and those of Longstone Moor and Rockhurst, on the other. This boundary is located around the elevated ground to the south of Peak Forest, and to the east of Dam Dale (Figure 4.19b).

Another area of land of high cumulative visibility is that between the Five Wells passage grave, between Taddington and Miller's Dale, with cells in view from Perryfoot, Harrod Low, Longstone Moor and Rockhurst (Figure 4.19c). Of particular note is the very narrow (50-200m) east-west running boundary between the Longstone Moor and Rockhurst viewsheds, in which all the Long Barrows are represented except Gib Hill. In this sense, the viewsheds of Longstone Moor and Rockhurst are not dissimilar to those of Tideslow and Minninglow, with sharply defined boundaries here and running along Longstone Edge.

A final palimpsest of intervisibility is to the land immediately west of the Bole Hill Great Barrow, on Bole Hill, at the head of Kirk Dale. These cells have values indicating a combined viewshed of Gib Hill with either Harrod Low to the north, or Rockhusrt to the south; or a combination of all three. Being sited slightly to the north of the top of this feature, the barrow avoids this area of intervisibility by as little as 50 metres (Figure 4.19c).

4.6.3 – Passage Graves

The definite examples in this group are Five Wells, Minninglow, Harborough Rocks and Green Low, with Pea Low and Stoney Low again as possibles, which are later embellished to become Great Barrows. Figure 4.20 shows the area of these viewsheds, and as with the other groups, shows noticeable variation. Five Wells, Minninglow and Harborough Rocks have the larger viewsheds, of 109, 146 and 172,000 m^2 respectively, also being the largest three viewsheds in the study area. Green Low, and the possibles of Pea Low and Stoney Low are significantly smaller, at 32, 25 and 24,000 m^2 respectively.

Green Low, as mentioned above, has the smallest viewshed of the definite Passage Graves, and is also quite locally defined. Much of this viewshed overlooks the land above the Grange Valley, a potentially significant route way, which today is followed by the Via Gellia (Figure 20a). Forming a potential major entry point into the south east of the White Peak, it would be difficult to exit from this valley into the uplands above without entering the viewshed of this monument. Interestingly, the other significant component of this viewshed is the land around Taddington Moor, running up to (but not including) Five Wells.

In stark contrast to this are the viewsheds of Five Wells, Harborough Rocks and Minninglow. Five Wells is interesting as it is the northern most member of this largely southern group, sitting just north of a significant linear topographic feature that delineates the northern edge of Taddington Moor, running between Taddington and Chelmorton. From this vantage point it commands views that include significant tracts to the north and south of the Wye Valley, running as far west as the River Wye's source on Axe Head Moor (Figure 4.23). Much of this land is to the north of the Wye, and includes the uplands above Ravensdale, Tideswell Dale, Monks Dale (as far as Perryfoot and Harrod Low) and Great Rock Dale; as well as land to the north and east towards Tideslow and parts of Longstone Moor. Harborough Rocks has the largest viewshed of all the monuments in this study, and is also located on the highest ground. It shares much of its viewshed with Minninglow (discussed in 4.6.1 above and 4.6.5 below), although is more extensive, and is shown in Figures 4.21 and 4.21a.

The point-to-point intervisibility of the monuments in this group is shown in Figure 4.22, and again shows some interesting relationships. Minninglow, Harborough Rocks, and Green Low, along with the less certain Stoney Low, form a relatively distinct cluster in the south east of the White Peak, between Roystone Grange (near Ballidon), Aldwark, and Brassington. Harborough Rocks' viewshed just includes Green Low, Minninglow and the Rockhurst long barrow. Whilst as pairs, Minninglow and Harborough Rocks; and Green Low and Harborough Rocks are intervisible, Green Low and Minninglow are not,

with Green Low sitting outside the viewshed of Minninglow by a margin of less than 100 metres. Stoney Low sits outside the viewshed of its three neighbouring passage graves, although its own viewshed just includes Minninglow and Rockhurst.
The viewshed of Five Wells does not include any of these southern group, instead being focussed almost exclusively on the northern half of the region. Many of the barrows in this part of the limestone fall within its view area, including Harrod Low, Rockhurst, Bull Ring, Longstone Moor and Gospel Hillocks long barrows, the Tideslow closed chamber/Great Barrow and Windlow possible closed chamber. Of all the monuments located north of the Wye, only The Tong and Wardlow (possible long barrow and closed chamber type respectively) are excluded from the Five Wells viewshed (Figure 4.23a).

The simple Cumulative Viewshed Analysis results are shown on Figure 4.24. Cursory inspection suggests that many of the areas in view of the southern cluster of monuments are viewed by multiple monuments – in some case as many as five. By contrast, much of the area north of the River Wye is only in view from one monument, with the notable exception of the area around Tideslow Great Barrow, and further north again, around Kinder Scout, and the upland areas above the Howden and Ladybower reservoirs. Again this technique only gives an index of intervisibility.

The Two-Series Cumulative Viewshed Analysis has been simplified again to show just the overlap zones between two or more viewsheds, and is shown on Figure 4.25. Looking again at the land around the south-eastern cluster of passage graves, much of the land overlooking Grange Valley is covered in palimpsests of viewshed from these southern representatives. Visitors to the limestone plateau entering from this important access route would very quickly find themselves in the viewshed of one or more of these monuments, as shown in Figure 4.26 (which is a 2 series cva not simplified for overlaps).

Using this data to look at the land around the Tideslow great barrow, this monument sits just inside an area of land within the viewsheds of Five Wells, Minninglow, and Harborough Rocks, at the point where these three viewsheds intersect (Figure 4.27). This monument would only need to be sited 100 metres to the north of its location to be outside the viewshed of all three, or a similar distance east or west to be in the viewshed of Five Wells, or either Minninglow or Harborough Rocks. The other notable areas of intervisibility are, as with other groups, on the land immediately to the south of Five Wells, and the land around the Bole Hill great barrow. As in the case of the long barrows above, the Bole Hill barrow sits just outside this area of land that is shared between Minninglow and Harborough Rocks.

4.6.4 – Monuments by Geographical Grouping

Before considering the whole Peak District as one inclusive group, we will look at the monuments by geographic location rather than typology, effectively treating them as contemporaneous features. In doing this, the region is divided into five zones corresponding to those defined by Barnatt (1996a).

4.6.4.1 - North Western Zone.

The definite examples in this zone are Perryfoot, Harrod Low (definite long barrows), The Tong, Gospel Hillocks, Bull Ring (possible long barrows), Windlow (possible closed chamber), and Five Wells (definite passage grave), shown on Figure 4.28). The viewsheds of these monuments has already been partly discussed in section 4.6.2 above, with regards to the Perryfoot and Harrod Low long barrows. As mentioned above, these two, along with The Tong, form a complex pattern of intervisibility over Monks Dale, north of the Wye. Harrod Low and Rockhurst are not intervisible, but both are visible from the Tong, which is for kilometres further south towards the Wye. Travellers moving north up above Monk's Dale from the Wye valley would encounter the viewshed of this possible long barrow, and Harrod Low before encountering that of Perryfoot. The viewshed of the Tong extends as far westwards as the beginning of the viewshed of Windlow, where it is truncated. All three long barrows share this visible spur of land approaching the Windlow barrow, but this view stops approximately 100metres short of this possible closed chamber monument. Part of this spur is also visible from Windlow, so standing at this point, all four monuments would be in view. Windlow is intervisible with Tideslow, to the east, forming a visual connection between this area and the North/North Eastern Zone (Figure 4.29).

Standing somewhat away from these barrows to the west, the Bull Ring long barrow appears somewhat isolated from this cluster on initial analysis. Using a Two-Series Cumulative Viewshed Analysis to provide a more detailed picture, the viewshed from this monument is almost totally exclusive, apart from a very few restricted areas on its eastern edge, where it overlaps with others. At the natural feature of Bee Low, this is shared with Perryfoot and the Tong, and at Peak Dale, with Perryfoot (Figure 4.29).

Discussed in section 4.6.3, Five Wells is the southern most member of this (arbitrary) grouping. Its broad viewshed has been described above, and when added to those of the long barrows above, creates a comprehensive pattern of coverage over the uplands of much of this zone. Five Wells is the only member of this group to include Gospel Hillocks, Bull Ring, Perryfoot, Harrod Low, and Windlow (although marginal) in its view, excluding only The Tong. This monument also provides a visual interconnection with the North Eastern group, having Tideslow within its viewshed.

4.6.4.2 - North Central and Eastern Zone

The examples in this group are Tideslow (closed chamber and Great Barrow), Longstone Moor (long barrow) and Wardlow (possible closed chamber). The viewsheds of Tideslow and Longstone Moor have been described in sections 4.6.1 and 4.6.2 respectively. Taken together, their viewsheds cover much of this region, with intervisible zones around Foolow, Stanley Moor and Eyam. Visitors entering into the limestone from the north-east around Grindleford or Stoney Middleton would soon encounter the viewsheds from either or both of these.

Wardlow and Longstone Moor are both visible from Tideslow. Wardlow and Tideslow are intervisible, but Wardlow and Longstone Moor, whilst located in quite close proximity, are not. Longstone Moor interestingly does *not* include Tideslow in its view, which given that Longstone Moor itself does fall within the viewshed of Tideslow, has important implications regarding assuming reciprocity of view across such a topographically varied landscape. Wardlow's own viewshed appears to fill a gap left by the combined viewsheds of the other two, and the viewsheds of all three are shown in Figure 4.30.

The viewsheds of all three monuments in this group are truncated to the south by Longstone Edge, and none of the areas between this natural feature and the Wye are in view from this group. This lower region is in view of Bole Hill, Minninglow and Harborough Rocks, belonging to the central and South Eastern groups. The importance of this feature as a natural boundary between zones will be discussed below (4.7.1). The Tideslow barrow also provides a visual bridge into other zones, with its viewshed stretching into the Central zone, towards Gib Hill, and the South Eastern zone, towards Minninglow.

4.6.4.3 - Central Zone

The monuments in this grouping are Bole Hill, Ringham Low (closed chamber and Great Barrows), Gib Hill, One Ash (certain and possible long barrows) and Smerril Moor (possible closed chamber). The viewsheds of Ringham Low and Gib Hill have been qualitatively introduced in sections 4.6.1 and 4.6.2 respectively.

With the exception of Bole Hill, these monuments together create a more or less continuous swathe of visible land, from Five Wells to the north, down to the cluster of passage graves in the South Eastern group, and is largely delineated by the extent of this central part of the limestone plateau. Bole Hill's viewshed is more outward facing, looking towards Tideslow, and between the Wye and Longstone Edge to the north, Calton Pastures and Stanton Moor to the immediate east, and much of the Eastern Moors beyond, from Big Moor down to Beeley. The viewsheds for this group are shown in Figure 4.31.

Ringham Low and One Ash exhibit an interesting articulation of the landscape, in the areas immediately around the top of Lathkill Dale. Being just intervisible, their viewsheds largely ignore each other, instead providing complementary and quite extensive coverage of the northern Central zone. Taken as a pair, their viewsheds seem to form a north-south divide, with which Gib Hill and Smerril Moor also taken as a pair, provide complementary coverage of the southern part of this Central zone. This boundary is to the immediate north of Gib Hill, and is in view of all four monuments. Gib Hill and Smerril Moor are intervisible, but Bole Hill sits just outside land visible from Gib Hill, Ringham Low and One Ash.

4.6.4.4 - South Eastern Zone

This cluster comprises Minninglow, Green Low, Stoney Low, Rockhurst and Harborough Rocks. With three of these being definite passage graves, their viewsheds have been partly discussed in section 4.6.3. The typologically atypical Rockhurst long barrow sits just intervisible with Minninglow, Stoney Low and Harborough Rocks, but Green Low sits just outside this envelope. In addition to their local view over the Grange Valley, the group are noticeable in that all its members share extensive views of the southern and northern Central Zone, towards Gib Hill, and towards Five Wells further north; and further north again, below Longstone Edge, and the land around Tideslow (Figure 4.32). This extensive view is quite distinct in character to the more "inward" looking North Western and Central zones, although these have their exceptions.

4.6.4.5 - South Western Zone

This zone contains Long Low (closed chamber, long barrow and Great Barrow), Pea Low, Bostern and Stanshope. Some of the viewsheds for this zone have been described in section 4.6.1 (Figure 4.8). Together these monuments form a complex palimpsest of cumulative visibility, covering a fairly continuous tract of land between the Rivers Manifold and Dove, and East towards Tissington and Alsop Moor.

Like the South Eastern group, this group also has views to the north. Although there is some intervisibility between the members of these groups e.g. Long Low and Minninglow, there does also seem to be a noticeable general east-west division of the land held in view by these groups. Also noticeable is the lack of land held in view by this group towards the Central zone of the limestone, around Gib Hill, Ringham Low, One Ash and Bole Hill. Looking at the above groups, there does seem to be qualitative evidence for these monuments occurring in loose clusters, and that these monuments exhibit some degree of zonality in the local nature of their viewsheds, in many cases overlooking land and topographic features that would be obvious "entry points" into the limestone areas of the Peak. Also however, as has been noted frequently in the above, there are many cases where the viewsheds from monuments extend over great distances, and often including many other monuments. The implications of this for broader social integration and medium/long range mobility and exchange will be examined in the discussion.

The simple Cumulative Viewshed Analysis for all definite Neolithic monuments is shown on Figure 4. 34. It is clear from this that whilst many areas are only in view of one monument, there are definite "hot spots" of intervisibility. Some of these appear to form boundaries, and in some cases these naturally reflect topographic features, as immediately south of Five Wells, and along Longstone Edge. Another interesting boundary zone is that around the central core of the limestone, between Gib Hill and Ringham Low. Amongst others, this is a sharp boundary between Minninglow and Tideslow, whose viewsheds extend over much of the southern and northern parts of the region respectively.

4.6.5 – The Great Barrows and Henges of the Later Neolithic.

With the exception of the henge monuments, the viewsheds of all the other Late Neolithic burial monuments have already been qualitatively discussed above. Barnatt has suggested that these later monuments fall into five broad geographic grouping, similar to those used in section 4.4 above. The North Western zone, now only comprised of the Bull Ring henge, appears in viewshed terms very small and isolated. Using the 2 Series CVA, to identify overlap zones, it does share small areas of land with Tideslow, Bole Hill, and although not a Great Barrow, also Five Wells. Almost equally "isolated" is the South Western zone, wherein Long Low and Pea Low share quite a lot of land with each other, very little is shared with other monuments outside this zone.

Less obviously distinct are the North Eastern, Central and South Eastern zones. Large tracts of the Northern Central zone are in view of Arbor Low and Minninglow, and similar quantities of land between Longstone Edge and the Wye are shared by Minninglow and Bole Hill. As with the inclusive groups in section 4.6.4, these zones retain the "local" character of their viewsheds, as well as providing far-reaching vistas into other zones.

As seen in other sections above, the 2 Series CVA method allows the identification of interesting boundary and "hot spot" phenomena. The limestone ridge running between Five Wells and Bole Hill again is interesting, being in view of Bull Ring, Arbor Low, Minninglow and Tideslow (Figure 4.36), as is the land around Bole Hill itself. To the North of this natural feature, the barrow sits on land in view of Minninglow and Tideslow. Immediately to the south of this natural feature, is a boundary which is a palimpsest of viewsheds from Arbor Low, Minninglow, Tideslow, and the Bole Hill barrow itself.

The strikingly opposing viewsheds of Tideslow and Minninglow have been described in section 4.6.1. One area where this boundary is very sharply defined is in the Central zone, and it is difficult to ignore the siting of the Arbor Low henge monument to within 200 metres north of this apparent "border", technically within the viewshed of Tideslow, not Minninglow (Figure 4.37). Arbor Low's viewshed looks almost exclusively to the north, with much of this land being between itself and Five Wells and Bole Hill. Also in view is land around Tideslow, the western half of Stanton Moor to the east, and the western gritstone edges of the East Moors. Land to the immediate north not in view from this henge monument is in view of Ringham Low, and the viewsheds of the two are largely exclusive, although the monuments themselves are intervisible. Although typologically similar, the viewsheds of the two henges are strikingly different, with that of the Bull Ring being far more diminutive (Figure 4.37a)

With this grouping being the last in the sequence of Neolithic monuments, it is inviting to ask how the viewsheds of this group compare to those of the earlier monuments. In terms of size of viewshed, this grouping is larger than any of the typological groupings, but is smaller than the total viewshed for all definite Neolithic monuments group. This can be demonstrated graphically by identifying areas in either grouping and identifying the difference.
This can be demonstrated graphically by performing a 2 series CVA of the two groups, which identifies the discrepancy between the two coverages (Figure 4.38). Although discrepancies exist across the region, perhaps most striking is that around the north of the Wye, in the north western zone. This discrepancy can almost totally be accounted for by the Five Wells viewshed, which is not included in the Great Barrows schema. The implications of this are discussed below.

4.7 - Discussion

Current hypotheses regarding the role of these burial monuments within the broader Neolithic landscape (physical and social), and the specific questions outlined in Section 4.5.2, provide a useful structure within which to situate the complex patterning of the many viewsheds described in Section 4.6, as well as inviting their appraisal in the light of this analysis.

4.7.1 - General Thoughts on Settings – Topography, Viewshed area and Hydrology

As has been noted throughout the Results section above, there is noticeable heterogeneity in the size of the viewsheds from the different barrows, and that this exists within and between both typological and geographical groupings. This is very apparent when looking at Figure 4.39, which shows the viewshed areas for all the Neolithic barrows in the region. Not surprisingly viewshed area is at least partly correlated with height (shown on Figure 4.2), but this relationship is not strictly linear. The highest monuments do not always have the largest viewsheds, or include the greatest number of other monuments in their vistas, as shown in the case of Five Wells, compared to Tideslow. Other aspects of the character of the land around these monuments also come into play, and a good example of this is at Five Wells. The limestone outcrop immediately below this tomb is possibly referenced by the location and orientation of this monument (c.f. Tilley 1994). In addition the very subtle rise in elevation of the land immediately south of the monument effectively structures the viewshed, and therefore the experience of those visiting the monument by filtering its view almost exclusively to the northern half of the limestone Peak (Barnatt 1996b). If viewsheds were an important factor in choice of monument location, it would appear that there were other characteristics of these that were significant over and above size.

Hydrology, like visibility, is also heavily influenced by topographic features. The viewsheds of many of the monuments overlook land above the major rivers of the region, but also overlook many potential smaller stream beds leading out of these larger valleys, and up on to the limestone uplands. This was alluded to in the previous section, and can be visualised very clearly by the addition of the stream networks as predicted by rudimentary hydrological analysis. Notable examples are the closed chamber group of the south western part of the region (Long Low, Pea Low, Stanshope and Bostern), and the long barrow cluster from the north west (Perryfoot, Harrod Low, The Tong). In both these cases, the monuments are all enclosed within the same watershed, as shown on Figures 4.40.

These views over major rivers and minor tributaries have important implications for mobility through the region, especially for those with stock on the move as part of the seasonal round (Barnatt 1996a, Edmonds and Seaborne 2001). At certain times of year, the river valleys may have provided easy access routes for those settling on the shelves above, but at others they could be impenetrable and hostile. Equally, dense vegetation could prove a serious impediment to movement, certainly at summer. The numerous smaller tributaries would provide ideal routes out of the major valleys into the potentially more easily navigable uplands for two reasons. Firstly, at least some of these will follow terrain that is more suited to the herding of cattle than the more precipitous valley sides. Secondly, they would provide an essential source of water for these cattle on the move.

Whatever the motivation, there are many such potential streams out of which to leave the main river valleys, and very soon travellers would be in view of the ancestral houses, be they those of their own kin, or others. Whilst they would probably already know whereabouts they where physically and geographically, being in the presence of the ancestors would help locate them within a whole raft of social and spiritual meanings, and provide them with a sense of "how to go on" (Tilley 1994: 16). Maybe the passing of caves, natural features in the valleys and dales that also housed the dead, would also play the part in guiding travellers along the intermediary part of the journey, perhaps stopping to contemplate good fortune for the journey ahead. Whilst in many cases the stream networks appear to lead *towards* the barrows, in no cases do they right up to them, and are generally higher up above them in the same watershed. In a few cases e.g. Gib Hill, these approaching streams appear to sit just outside the viewshed of the monument, although this effect is very marginal, is probably on the limits of both DTM and analytical algorithm accuracy, and would require field examination to substantiate.

It has been suggested that seasonal pathways followed by Neolithic herders would echo those taken by their Mesolithic hunter-gatherer forbears, and that the location of these monuments may echo an already ancient sense of "place" within the landscape. This is can be demonstrated by evidence for Mesolithic activity directly beneath, or in the vicinity of Neolithic monuments, and is certainly the case in the Peak, as demonstrated at Green Low, Minninglow, Harborough Rocks and Gib Hill (Barnatt 1996a). The Green Low passage grave sits overlooking the land above the Grange Valley and the Via Gellia, as described in 4.6.4, suggesting that this route-way could have been of great significance during the Mesolithic. Harborough Rocks may have had significance as a striking natural feature during the Mesolithic. In functionalist terms, it could have served as a vantage point over the plateau below, where patterns of vegetation, and consequently, movement of wild animals could be surveyed (c.f. Krist and Brown 1994). In symbolic terms, it could have been imbued with the spirit of the ancestors (Tilley 1994).

The examples above illustrate the implications that the viewsheds would have over mobility at a local scale. It is also possible that the monuments with the larger and more extensive viewsheds could help structure patterns of mobility at a broader scale. It would be quite possible for example, to navigate from the north of the region, to the south, using a combination of viewsheds from many different monuments as a form of guidance system, and this might be of relevance whilst travelling on longer journeys, potentially over less familiar land. These larger viewsheds would also provide a sense of interconnectivity between the different geographical zones, and this itself may have been an important role of the Great Barrows, as many of these monuments exhibit these larger viewsheds.

One final aspect of mobility to consider here would be how people actually approach the tombs themselves. As mentioned above, many of the monuments could be approached by following stream networks, although the monuments themselves may be hidden from these. Many of the monuments appear to sit within a small island of their own visibility, but then this is often surrounded by land not held in view. This can be quite clearly demonstrated at Longstone Moor. Approaching such monuments would entail traversing land where the monument is hidden, followed by a final sense of revelation as the monument comes back into view at the final approach (Edmonds 1999a, Roughley 2001).

One interesting and slightly unexpected result of the analysis has been the identification of parts of the landscape that have very high cumulative viewshed scores. Some of these exist is fairly isolated hot-spots, as at Bee Low in the north-western zone; and others exist as linear features, and creating the impression of "boundary zones", as at Five Wells and Longstone Edge. Not surprisingly, many of these are caused by the interplay between the location of the monuments, and the topography of the landscape. The analysis has enabled the identification of an unexpected phenomenology of landscape, where rather than looking for significance in natural features in close proximity to the monuments to account for their location, the location of the monuments themselves create meaning, and add to the general milieu of the socially constructed landscape. The construction of such monuments "can invest significant natural places with additional layers of symbolism" (Bradley 2000: 107).

Whilst it is impossible for us to know exactly how this meaning was played out in terms of broader social relations in the Neolithic Peak, it is interesting to note that recent rescue excavation work at Longstone Edge by English Heritage has revealed a Neolithic mortuary enclosure, with several burials, interred in rock cut graves, and that this enclosure is located within the viewshed boundary zone of this prominent natural feature.

Many of the monuments include areas of the northern massif in their viewsheds. Barnatt has suggested that this zone may have importance, both as a connection with the wild, but also for activities such as rites of passage (1996a). For many these may have been places once visited, but long ago - places on a distant horizon of both view and memory, but still significant, and still there.

4.7.2 - A Chronological Interpretation

Although the chronological sequence of barrow typology proposed by Barnatt is only really substantiated by the excavations at Minninglow, it does provide one convenient model on which to structure the interpretation of the viewshed data over time, between the Early to Late Neolithic.

Taking the Closed Chamber types, followed by the Long Barrows as being the earlier monuments, the viewshed data suggests that in many cases, local concerns were enough, and that the tenure over the landscape was largely negotiated at this scale. This is most clearly illustrated by the closed chamber group of the south west of the region, and the long barrow cluster of the north west. In both cases the complex patterns of intervisible land would suggest that some level of understanding between the builders of these different monuments enabled tenure over these parts of the landscape to be shared. It is not possible to determine from this data alone what the exact relationship between these monuments would be, and at what sense of scale each one operated. It is possible hat each monument effectively "belonged" to a particular kin group, providing that groups claim of tenure over particular areas; or it is equally possible that a more subtle and dynamic system of co-operative monument building and sharing of landscape resources between several kin groups was at play. In the case of the Long Barrows of the north-west, Harrod Low and Perryfoot may have represented two different kin groups, which held a more distant and over-arching connection reinforced by shared ancestors at The Tong.

In the Early Neolithic, issues of tenure were resolved at a relatively local scale, but as time went on, concerns appear to have grown wider. This is suggested by the emergence of the Passage Graves, with three out of the four definite examples having the three largest viewsheds in the study area, and including more monuments within these than any other group. This could suggest that not only had the scale of tenure increased, but also the scale of the seasonal round, implying new patterns of mobility. Economic arguments typical of the New Archaeology may have invoked increased population pressure as a driver to herd more cattle (Thomas 1999, Edmonds and Seaborne 2001). An alternative argument is that cattle became more important throughout the Neolithic to satisfy demands for ritual practice rather than subsistence (Tilley 1994). Herders who for whatever reason needed to increase the number of their stock would ultimately need to increase the size of their grazing lands, and this could entail grazing their stock over larger areas, and possibly further away, for longer periods of time. Another possibility is that patterns of settlement and seasonal mobility were changing altogether in favour of a more sedentary lifestyle, and evidence for this is emerging as more lithic evidence is gathered across the region (Edmonds and Seaborne 2001).

At the time of the emergence of the Passage Graves then, concerns over tenure may have been operating at broader scales than in the Early Neolithic. Passage Graves differ from the other two types in that architecturally, they are designed to maintain access to the remains of the ancestors held inside, whereas with the Closed Chamber and Long Barrow types, access to the ancestors was effectively sealed off by the act of the raising of the mound. Many authors have argued that this commitment to accessing the remains of the ancestors, structured with earth and stone, along with bone assemblages that were anatomically incomplete facilitated the circulation of the ancestors amongst the living (Thomas 1999). As well as operating on a broad level of spiritual meanings, this could also serve a more political purpose, as the circulation of the corporate body of the ancestors amongst the living might help to serve an integrative purpose amongst different kin groups, who may themselves lay potentially competing claims over tenure. Perhaps their historical association with the land in a partitioned way was starting to ameliorate.

It is interesting then that the Passage Graves viewsheds not only cover very broad areas, but also encompass many of the "earlier" and more local examples. Although this observation has not been tested statistically, it is consistent with that of Roughley, who noted that the Passage Graves around Carnac had larger viewsheds than the Earthen Long Barrows she studied (Roughley 2001). This is very strikingly demonstrated by the viewshed of Five Wells, which as well as commanding a large view over the uplands flanking the river Wye and beyond to the north, also seems to perform an integrative role between the monuments in the north west, and with Tideslow in the North East. Similar patterns are seen to the south of the limestone with the Passage Graves of Harborough Rocks and Minninglow – both monuments have very large viewsheds, which are inclusive of many other monuments. Interestingly, whilst some of the clusters of earlier monuments sit within the same watersheds, Five Wells, Minninglow and Harborough Rocks sit on or close to the boundaries between two or more watersheds, and their viewsheds cross many. As well as having practical significance for grazing cattle, these watersheds may have held deeper significance in the Neolithic, and again may have had implications for the articulation of tenure over the land (Barnatt 1996a, Edmonds and Seaborne 2001).

Following this chronological trajectory take us to the Later Neolithic. At this time, many earlier monuments seem to fall out of use. Those that remain became structurally embellished, closing off direct access to the remains of the ancestors (Barnatt 1996a). Instead of experiencing their presence directly, communing with the ancestors for many was mediated by a few, or one. For whatever social or economic reasons, concerns had now outgrown the integrative nature of the Passage Graves, and were now arguably operating at the sort of scale suggested by Barnatt's regional grouping of monument complexes. Veneration of the communal ancestors at a local scale may now have become less important.

In viewshed terms, Barnatt's zonation of Later Neolithic monuments is largely corroborated, although the boundaries are not rigid, with certainly the Tideslow and Minninglow barrows having viewsheds that extend far into each other's, as well as the Central zone. One area of ambiguity however rests with the relationship between the Bole Hill Great Barrow, and the other monuments of the "Central" zone. It is anomalous in two ways. Firstly the barrow's viewshed look almost exclusively towards the north-eastern part of the region, including Tideslow, and a large swathe of land between the Wye and Longstone Edge. Secondly, like Five Wells, it is geographically located just outside a boundary of viewsheds created by the other constituents of this group (Arbor Low and Ringham Low). It shares some of its immediate viewshed with Tideslow, but also some of this land with Minninglow. This anomaly could be explained in terms of seasonal mobility. The low-lying shelves above the River Wye could have been an important location for over-wintering and settlement. This locale presents several immediate choices for migrating to seasonal pastures – either north towards Tideslow, West down the Wye towards Five Wells, or south east, towards the Central and largest zone. For these people the Bole Hill barrow may have provided an important symbol – acting almost as a gateway that once passed, travellers would immediately enter the palimpsest of viewsheds described above. This barrow's focus may have changed over time – it could itself have addressed very local concerns in the Early Neolithic, in the areas south of the Wye near Bakewell, but then have been recruited as part of a larger monument complex by the Later Neolithic. Unfortunately the archaeological evidence for this site is particularly poor, so little can be said about its architectural history that can inform further interpretation (Barnatt and Collis 1996). An alternative explanation to this was that Bole Hill acted as a Great Barrow independently of the Central group, acting as a focus to this potentially important settlement zone around the Wye.

If the Great Barrows were to become regional foci that effectively made the earlier monuments redundant, then in superficial terms at least, it might be reasonable to expect the viewsheds from these monuments to do likewise. As described in section 4.6.5, comparing viewsheds of all the definite Neolithic examples, with those just of the Great Barrows and henges shows that this is largely the case, apart from a major discrepancy to the north of the Wye, westerly from Five Wells, and it does seem strange that such a significant area of land not be represented in the later viewsheds. Most of this discrepancy can be accounted for by the Five Wells viewshed. This large Passage Grave, with its large viewshed inclusive of many other monuments, and sitting very close to the boundary between two important watersheds, seems to have the characteristics of a Great Barrow, although is not classed as one by Barnatt (1996a, 1996b). Bearing this in mind, the discrepancy between the Middle and Later Neolithic viewsheds can be explained in one of two ways. Firstly, the land in view from Five Wells was no longer a concern to later Neolithic herders in the way it had been earlier, with their attention becoming more focussed on the Central zone. Secondly, it could be that Five Wells' history did extend into the Late Neolithic, and that it too became a Great Barrow. Like Bole Hill, it too could have acted as a gateway to the central limestone plateau, providing visual interconnectivity between the Central zone, and the Bull Ring to the north west, and Tideslow to the north east. Like Bole Hill, it could also have acted as a focus for a separate zone not included in Barnatt's schema. A third possibility (extending from the first) will be discussed in the context of the Bull Ring Henge below.

It has been suggested above that as the Neolithic wore on, a possible need to herd more cattle may have led to a need to increase the range of the seasonal round, and that exploitation of summer grazing resources would need to expand and diversify. For those in the more peripheral clusters of the north west, north east, south west and south east, expansion onto the best grazing land could well have necessitated extending their seasonal round from these more peripheral areas into the Central zone. It was in this zone that encounters with others would become ever more frequent, and with this perhaps, also more potentially volatile - perhaps the incidence of leaf shaped arrowheads that Bradley and Hart used as indicators of settlement may have in fact reflected a more sinister development in social relations in the Late Neolithic.

Increasing pressure was possibly being placed on the Central zone as a resource by the whole region. As time went on, so the need to find resolution to potentially emerging conflict, via negotiation, also increased. This resolution finally came with a commitment to place via a new form of architecture – the Arbor Low henge. The siting of Arbor Low is quite remarkable for two reasons. Firstly it sits very much at the heart of the whole limestone region, equidistant from the northern and southern margins, and also east west within the central zone. Secondly, it sits right on the border of the viewsheds of Minninglow and Tideslow, now Great Barrows which themselves would have been important foci at a zonal scale. The significance of this may have been highly symbolic, as well as it's pragmatic location on the boundary between two of the largest and opposing viewsheds in the study. The monument, with its symbolic circular bank and internal ditch, also sits just north of a boundary between two important watersheds, and could have been a focus for negotiation of tenure and resolution of conflict for the whole region.

The setting of the Bull Ring, the other henge monument in the study area, contrasts quite sharply with that of Arbor Low, and this can be explained within the general context of the north western monuments. Even in the Early

Neolithic, this zone appears somewhat isolated from the rest of the regions in viewshed terms. If it is true that Five Wells did fall out of use around the Late Neolithic, then this sense of remoteness is exacerbated, as Five Wells' viewshed is effectively the only visual link between this group and the rest of the region. This isolation seems to become more explicit with the siting of the Bull Ring henge, which pulls the focus of this group *away* from the central limestone core. It could be that the concerns of people in this region were quite separate from those of the north-eastern, central and southern regions, and this would corroborate Barnatt's argument as to the role of the two henges as regional foci for groups separated by the River Wye. If this were the case it again could reinforce Five Well's importance as a site of extreme importance in the Later Neolithic, providing a vital sense of integration between the more peripheral groups of the northwest and northeast on the one hand, and the northern margin of the central zone on the other.

This does not necessarily mean that the people in the north west had become totally isolated from the rest of the region, and an alternative explanation for the Bull Ring henge might be that it performed a different role to Arbor Low. Rather than being a central place of public gathering and negotiation, it could have been a far more private place – for contemplation, or, being closer to potentially more liminal landscape zone of the northern massif, a place for celebrating rites of passage. Equally, the Bull Ring henge may have functions outside of this study area, or indeed, like Arbor Low within the region, may have acted as a statement between regions - a junction perhaps between the Peak District and the Cheshire Plain beyond.

It should be stressed that there could be many mechanisms at work which led to the widening of scale of peoples concerns towards and during the Late Neolithic, over and above the fairly simplistic demand for more grazing land as outlined above. Barnatt has suggested it is during this latter period that subsistence gradually starts to shift more towards settled agriculture, with more people "inhabiting family farms" (1996a: 54). During this time, perceptions of tenure may have become less communal, and the desire to more permanently and visibly partition the land was starting to emerge. It is also around this time that we start to see the proliferation of the "single burial" round barrows, that abound on both the limestone and the Eastern Moors. Many authors have suggested that the focus of tenure was shifting back to more restricted kin groups, and that changes in burial practices were now starting to suggest the emergence of "individuals", hierarchies and increasing social differentiation. There could be many reasons why it was important to travel to the henge monuments at particular times for certain key events– the needs to participate in the trading of exotic new domesticates and technologies, find exogamous mates, and be seen to exert influence in a changing social order are just a few.

4.7.3 - Non Chronological

As stated many times throughout this work, the chronological sequence as discussed above is not supported by a great wealth of evidence, and so we must concede that it is potentially insecure, and consider the alternative – that the Closed Chamber, Long Barrow and Passage Grave types (at least) are broadly contemporaneous; and that also (not discussed above), that their use may continue into the Later Neolithic.

If these monuments did coexist, it would be reasonable to ask what was the significance of the differences between the three typological groups. One possibility is that different types represent activities of different kin groups, having tenure over different land. A potential way to demonstrate this would be to compare viewsheds of two or more adjacent but typologically different barrows. A good example of this comes from the North Western distributions, where the possible Closed Chamber barrow of Windlow, which although sited in close physical proximity to The Tong, Harrod Low, and Perryfoot, manages to sit just outside their viewshed. The second possibility is that all these monuments were used concurrently by the same extended kin groups, but for different functions or symbolic meanings – perhaps different categories of burial. Another possibility is that these different typological groupings simply represent a diversity of architectural expression. Although similar structural archetypes are employed in Neolithic tombs across Britain, there is also considerable local variation within this. The temptation to seek any one universal meaning amongst these typologies should be resisted (Bradley 1990, Thomas 1999).

4.8 Discussion

The overall aim of this chapter has been to investigate how GIS based analysis can contribute to current models about Neolithic activity in the Peak District. Whilst it is unwise to say the results of this analysis can *prove* these models, it can be said with some confidence that there results of the analysis are certainly consistent with, and lend weight to them. In particular, the viewshed data illustrates the importance of the ancestors in securing tenure over areas of the upland that would have been suitable for seasonal pasture for cattle. Equally the data shows how concerns over tenure may have changed over time, and how these may have grown from a local kin group focus to a larger regional one.

The data has shown one significant deviation from Barnatt's model of the Late Neolithic, which raises questions over the status of Five Wells as a Great Barrow. Although not actually classed as one, in terms of its viewshed and landscape setting, it very much seems to behave as one. This again throws up the broader issue regarding the state of preservation, and quality of excavation evidence for many of these monuments. Unfortunately this tomb has not been dug under modern conditions, with the only excavation evidence being that of Bateman in 1846, and Salt, around the beginning of the twentieth century (Manby 1958).

Related to this general problem is that of barrow classification – again because of historic damage to these monuments, some may have been identified as being Bronze Age in origin, whilst in fact they have histories that stretch back into the Neolithic. One example of this is at Stan Low, near Great Hucklow, where recent excavation has recovered a Neolithic human bone assemblage of ten or more individuals from beneath an allegedly Bronze Age barrow (Chamberlain *pers comm*). This suggests that we have not been working with a complete data set, and that the rate of re-classification of monuments would bear investigation for future work.

Many of the viewshed phenomena presented in the above two sections have shown monuments sitting just within or just outside of the viewsheds of other monuments. In these cases these monuments are located at the very margins of their own and other's viewsheds. It is important to remember that such phenomena may be artefacts of methodology, as discussed in the previous chapter and below. In such cases these phenomena need to be verified by field observation.

Another methodological consideration that plagues studies such as this is the potential effect of vegetation on viewsheds over a given area. This is particularly problematic for this study, as the amount of useful environmental data for this part of the Peak is very small. Although more substantial data exists for the Eastern Moors, caution needs to exercised in extrapolating these results to the limestone zone for a variety of taphonomic and interpretative reasons (see 2.3.2.2). Whilst it may be ultimately impossible to say what the vegetation was actually like during the Neolithic, we can at least model some possible alternative regimes using the landscape visualisation software, which is explored in Chapter 5.

One final methodological issue on which this study could be criticised is the choice of viewer height, which was the ArcView default value of 1 metre. Recent studies have suggested using heights of around 1.6 – 1.7 metres, as these correspond to average heights for Neolithic peoples based on skeletal evidence (Trick 2004, Woodman 2000). Because of concerns over how this may affect the results presented above, some preliminary sensitivity tests have been performed, using an observer height of 1.57 metres (which factors in the above, minus 10cm for the average height offset between the top of the skull and the eyeball). Not surprisingly perhaps, this does create a discrepancy. This discrepancy is demonstrated in the case of Tideslow in Figure 4.41. It should be noted that most of the discrepancy can be accounted for in the short and medium distances, with long range views largely unaffected. This could have implications for subsequent CVA results, especially when describing some of the more subtle and marginal phenomena, such as that around Five Wells, or the viewshed boundary between Tideslow and Minninglow. With this in mind, further testing has been performed for Minninglow, Five Wells, Harrod Low and Perryfoot. Although minor discrepancies exist in all cases, the results from the redone CVA and subsequent interpretation for these remain intact. The viewshed phenomena around Tideslow, Five Wells, and the Tideslow/Minninglow boundary effect at Arbor Low have been substantiated with ground truthing. In the cases of Tideslow and Five Wells, this ground-truthing has been demonstrated in Chapter 6, using Panoramic Virtual Reality (6.2.3 and 6.2.4).

One interpretative question that this study has raises concerns sites with long histories of use, and large and inclusive viewsheds. Because these sites are fixed in the landscape, one might assume so also are their viewsheds. The meaning of these sites in the broadest terms however does change with time, and so perhaps then does the meaning attached to their viewsheds. The builders of the early Closed Chamber monuments like Tideslow and Minninglow had no idea that their site selection marked the beginning of a 1,000+ year trajectory of changing social organisation, and their interests may have just been with the local viewshed, as a means for resolving local concerns. In any case such a long-term trajectory is an archaeological invention, not theirs (Barrett 1994, Edmonds 1999a). In these sites, the long distance viewsheds were affordances that were already there – what had changed over time was the desire or need to exploit them.

One final deficiency with this kind of study is this very format of presentation. The study has been trying to convey are notions of embodied landscapes, experienced at a human scale. In doing so it has only been possible to provide a limited number of illustrations, which portray a very Cartesian view of landscape space, and at a sense of scale only normally experienced by airline pilots. These issues will be addressed in Chapter 6, where PVR techniques will be used to create *embodied viewsheds* (c.f. Exon et al 2000).

A final concluding comment is to evaluate the outcome of this work. The study has been cautious to avoid suggesting that viewshed concerns were the primary causal agents in the siting of Neolithic burial mounds, but rather their location was dictated by a range of factors in a geographically and socially constructed landscape. One of these factors however could have been visibility, in terms of views from and views of the monuments, and that this visibility may not only influence their location, but be an active component in the structuring of this landscape, on social, economic and spiritual levels. Although the significance of point-to-point intervisibility of these monuments can be quantitatively dismissed (Joyce 1995), this data can not just be ignored, and requires further examination and explanation that quantitative analysis alone can provide. In doing so it is argued that qualitative studies of this nature provide a body of data and interpretation that add valid insights into our understanding of prehistoric landscapes.

Chapter 5 - Virtual Reality in Archaeology

5.1 - Introduction

The purpose of this chapter is to provide a general context to the Virtual Reality (VR) case studies presented in Chapters 6 and 7. The purposes of the case studies following this chapter are twofold. Those presented in Chapter 6 mainly focus on the use of Panoramic Virtual Reality (PVR) to represent monuments in their wider landscape context. In particular, three of the examples examine how PVR can enhance the presentation of the results of the viewshed analysis conducted in Chapter 4. The VR models presented in Chapter 7 focus on how the technology can enhance the understanding of a particular monument, the Arbor Low Henge (7.6.1.9), by providing an embodied encounter with its architectural form.

This chapter will start by introducing some of the necessary background concepts in VR, and its application in archaeology. It will then focus on some of the issues regarding the technology's use in representing landscapes, with reference to appropriate case studies. The final part of the chapter will address some of the critical issues encountered with representing monuments using three-dimensional (3D) solid models.

5.2 Defining Virtual Reality

The term "Virtual Reality" (VR) was first popularised by Howard Rheingold in 1991, although it largely referred to technologies that had been developing for up to 30 years earlier, such as Ivan Sutherland's invention of the "head mounted display" in 1968 (Earnshaw et al 1993). What has been described as VR in archaeology over the last 15 years has become so diverse that it is not easy to provide a single clear definition - a situation encountered in other disciplines such as geography (Barcelo et al 2000, Brodlie et al 2002).

Some authors define VR in more general cognitive and educational terms, as with Macpherson and Keppell (1998:3-4):

1 "Virtual Reality is a state produced in a person's mind that can, to varying degrees, occupy the person's awareness in a way similar to that of real environments."

2 "Virtual reality devices are devices that contribute to the creation of a virtual reality"

Or that:

"Any definition of virtual reality is further confounded by claims that it is not a technology, but a set of emerging phenomena which are enabled by another set of rapidly evolving technologies and informed by yet another set of sociocultural influences. VR is a set of rapidly evolving computer generated phenomena in search of a definition". (Moore 1995: 1)

Technical definitions however tend to be a little more specific, generally describing VR more in terms of an interface between a computer user and some representation of a "source reality". More specifically, these representations should be three dimensional, and facilitate exploration and manipulation by the user in real time (Frischer et al 2001, citing Cruz-Neira, 1997).

In reviewing a number of VR applications in geography, Fisher and Unwin have formulated the following definition: "Virtual reality is the ability of the user of a constructed view of a limited digitally encoded information domain to change their view in three dimensions causing update of the view presented to any viewer, especially the user" (Fisher and Unwin 2002,1). The authors note that whilst the popular image of experiencing such realities requires specialist hardware such as head mounted displays and haptic feedback gloves, most of the same information can be conveyed on a standard computer monitor, and be delivered by Web based technologies. Recent advances in processor performance and graphical display capabilities place the rendering of the necessary real-time dynamic images within the grasp of most modern office machines (Goodrick and Earl 2004).

As Brodlie et al point out (2002), VR is largely defined as an aspect of Human Computer Interaction, but it is the nature of the interaction with this representation that is perhaps the defining point. What is key to this interface is that there is effectively a "collapse" between the user and the representation, where the point of view of the user is effectively the interface or window into the virtual world. In many cases this takes the perspective of the "first person", as is commonly found in commercially available computer and "console" games. Implicit in this, is that VR can enable an *embodied* view and experience of the virtual representation (Chan 2000).

Both groups of authors clearly point out that the other major requirement of VR is the creation of the virtual world on the basis of some source reality – "the construction of a world to be explored" (Fisher and Unwin 2002: 2). Doing this requires an acknowledgement of the basis on which the construction is made. Given that in any representation there are invariably choices in exactly what is constructed and how, such choices should be made with regards to its final use, and they should be evaluated on their "fitness for purpose", rather than any "external criteria or pragmatic guidelines" (Brodlie et al, 2002: 11). This final point is of critical significance when confronting issues such as "realism" and "authenticity", as discussed below.

Taking these ideas together, for the purposes of this study, VR can be summarised by the following characteristics:

1. It is a user-controlled interface to a computer-based dynamic representation of a source reality
2. This interface often provides a first person, embodied view of the representation, allowing at the very least a sense of bodily movement
3. That this representation needs to be constructed

4. The choice of how and what is constructed should be dictated by the representation's intended use

So whilst most examples of VR in this sense share the concept of the first person, embodied interface with a representation of some source reality, it is the exact nature of both the representation *and* the source reality in which the diversity of VR lies.

5.3 Categories of use in Archaeology

The diversity of VR applications within archaeology is manifest in four main areas:

1. Static rendered images
2. Animated sequences, often referred to as "fly-throughs" (Barcelo 2000)
3. Interactive representations of landscapes
4. Interactive representations of monuments

The first two categories have most often been used for presentational purposes, and are generally not particularly interactive. Even photo-realistically rendered animations delivered via the web allow little more user control than simply starting and stopping the sequence. What the viewer actually sees is a predetermined view, whose narrative content is dictated by the animator. Typically such scenes employ cinematic camera techniques that can be deliberately choreographed to provide an abstracted, non-embodied view of the world (Earl 2006). An example of this can be seen in the recent reconstruction of the Huntsman Works in Sheffield (http://www.hrionline.ac.uk/huntsman/model_stage10.html). Because of their non-interactivity, these approaches are not considered as true VR in the criteria applied to this study, but are included because of their historical component within the history of virtual archaeology.

One advantage that such photo-realistic static and animated images can have over less detailed interactive models is that they can display things not currently deliverable in real-time interactive models. These typically include certain volumetric rendering effects such as shafts of light coming through an abbey window (e.g. at Santa Maria Maggiore, Frischer et al 2000, Lucet 2000), or the kind of seamless transition between the reconstructed site and its current location, as so skilfully demonstrated in the sequence of the Huntsman Works above. Where investigations or portrayals of such phenomena are the objective of such representations, this is of course fully justifiable. However when such approaches are adopted simply "because they can", such representations constitute an un-critical form of technological determinism.

The majority of attention in this study will be focused on the third and fourth categories. Both categories employ the navigational metaphor of the embodied first person perspective, and differ mainly in terms of scale of focus. Landscape representations typically use PVR approaches discussed below, or a navigable three-dimensional terrain surface corresponding to a modern physical environment (Exon et al 2000). Reconstructions of monuments generally entail the construction of an interactive three-dimensional model, using appropriate modelling software. Both forms of representation need suitable distribution media for dissemination, e.g. the Web (Brodlie and El Khalili 2002). It should also be noted that all the VR representations discussed in this study are of the "non-immersive" type. This means they can be experienced on a computer monitor rather than using specialised hardware, such as a "CAVE" environment (Vote et al 2000).

Both the ontological and epistemological developments of VR in archaeology share much in common with those of the adoption of GIS within the discipline (Goodrick and Gillings 2000, Goodrick and Earl 2004). These are summarised below

1. Early Claims of potential
2. Early descriptions of projects and methodologies
3. Results of early pioneering work
4. A phase of criticality

5. A post critical phase

One of the first publications outlining a use for VR in archaeology came from Paul Reilly, in his 1992 paper "Towards a virtual archaeology". Reacting against what he saw as the flaws in traditional publishing, Reilly proclaimed that the emerging technologies of computer based interactive multimedia and solid modelling would revolutionise the discipline in the fields of data recording, analysis and presentation. In more recent publications however, it is his definition of virtual archaeology that has received most attention "The key concept is virtual, an allusion to a model, a replica, the notion that something can act as a surrogate or replacement for an original" (Reilly 1992: 133). For some authors this has become an unwitting legacy that has driven the majority of developments since towards a quest for photo-realism (Gidlow 2000, Gillings 2002)

Archaeologists appeared quick to adopt the possibilities offered by VR techniques, and the early to mid 1990s witnessed a whole host of projects being spawned, and a number of publications outlining systems designs, data structures and modelling methodologies. Comprehensive reviews of many of the technical issues tackled are addressed in Barcelo (2000) and Frischer et al (2001). Large corporate bodies became involved in sponsoring high profile reconstruction projects of equally high profile heritage sites e.g. Pompeii and Stonehenge.

During the same general period, the results of these early projects were also being exhibited. 1996 saw the publication of "Virtual Archaeology", the first full publication dedicated to the use of VR in archaeology (Forte 1996). With its somewhat "coffee-table" format, the volume contains many lavish illustrations of photo-realistic rendered images, many from reconstructions of world-famous monuments. Although mentioning virtual models and animations throughout the associated text, no actual examples were provided, with no accompanying CD-ROM. In fact the book features more actual photographs of the extant sites being reconstructed than the reconstruction images themselves.

Towards the middle and late 1990s, just as happened with GIS, a number of authors began to critique this burgeoning body of reconstructions for a number of reasons. Firstly, it appeared that many of these projects, funded typically by large hardware and software manufacturers served mainly to demonstrate the prowess and performance of such systems, or for other questionable PR reasons, rather than make any real contribution to archaeological knowledge - BNFL for example are not normally associated with the pursuance of archaeological discourse (Miller and Richards 1995).

Secondly, although archaeologists may have been consulted on aspects of these reconstructions, they certainly were not in direct control of them, as it was computer scientists did much of the work (Goodrick and Earl 2004, Miller and Richards 1995). This resulted in at very best what can be described as "artistic licence" coming into play, and in most cases no explanation was provided as to why things were reconstructed in the way they were. Thirdly, the images give no indication as to levels of uncertainty within the reconstruction, with modelling techniques not able to "display levels of probability that a wall stood where it was shown" (Miller and Richards 1995: 20).

A fourth criticism follows directly from the third, in that whilst the application of "artistic licence" appears obvious to many in traditional reconstruction diagrams, the authority that conveyed in computer generated imagery creates the impression that such reconstructions are based on an unquestionable and knowable reality (ibid: 20, Bateman 2000, Eiteljorg 2000, Gidlow 2002, Kantner 2000). Static rendered images as in Forte's volume are exactly that – they provide no sense of embodiment within a world, and no opportunity to explore (Forte 1996). As mentioned above, animated sequences do little better in that all they do is present an imposed narrative about how the scene should be experienced.

A final group of criticisms questions whether the pursuit of photo-realistic models and images is a valid use of the technology in archaeology at all, instead stating that such models should be used as a way of *manipulating* and *exploring* archaeological data, rather than simply *presenting* it (Barcelo 2000, Kantner 2000, Gillings 1999, 2000, 2002, Gillings and Goodrick 2000). This final criticism is discussed in more detail in 5.5.1 below.

In more general terms, all these criticisms taken together creates an impression that VR techniques are expensive, need specialist skills and facilities, and basically beyond the scope of normal archaeological practice. This is not a climate in which many archaeologists will embrace the technology, and as a result, there will be fewer practitioners within the discipline working to resolve either important methodological or interpretative issues (Gillings 2002, Goodrick and Earl 2004).

As with GIS based studies, virtual archaeology has now reached a post-critical phase. More recent studies, although still few in number, are moving away from photo-realistic models for purely presentational purposes. Instead, recent authors are pursuing VR techniques to answer specific research questions, which themselves are driven by appropriate contemporary archaeological theory (Cummings 2000a, 2000b, Earl 1999, Earl and Wheatley 2002, Goodrick and Harding 2000, Pollard and Gillings 1998, Roughley and Shell 2004, Trick 2004).

5.4 Representing Landscape with Panoramic Virtual Reality

5.4.1 Panoramic Virtual Reality (PVR)

In a PVR representation, the user is effectively place inside a "virtual cylinder", with a panoramic image projected onto its interior surface. Navigation is provided in that the user can pan the image from side to side, tilt it up and down, and zoom in or out. Navigation is limited however as the user is anchored to the point (or *node*) from which the panoramic image was created. Nodes can however be linked together, allowing the user to jump between them, enabling the construction of a virtual "tour" around a monument or landscape (Edmonds and McElearney1999, Goodrick 1999, Larkman 2004). As with solid three-dimensional models, there is a range of software solutions for creating PVR worlds. Many of them automate the procedure of "stitching" a sequence of overlapping still images to produce the necessary panoramic image for viewing, e.g. Apple's QuickTime VR Authoring Studio. Some three-dimensional graphics packages also allow the exporting of models in the appropriate format.

An obvious attraction of this approach is that it can present both monuments and landscapes in photographic detail, and can be delivered using freely available Java based plug-ins, or as in this study, using Apple's proprietary but freely available QuickTime player. Extra functionality can be added to this approach by linking panoramas to static images e.g. maps, whereby a pointer in the static image dynamically indicates the direction in which the viewer is "looking" in the panorama. This approach has been called a "PanoraMap" where it has been used for creating "virtual field trips" in geography (Dykes 2002). It has also been used to link PVR representations with viewshed data by Exon et al (2000), and this approach has also been adopted in this study (6.2.2, 6.2.3, 6.2.4, 7.6.1.8). PVR representations have also been described as "Bubbleworlds" (Gidlow 2002, Goodrick 1999, Goodrick and Gillings 2000).

PVR representations can be used to depict the architectural form of monuments themselves, as in the examples of the West Kennet Long Barrow, and Arbor Low henge presented in Chapters 6 and 7 respectively. In many cases this has been from a purely presentational perspective, such as the Metis collection of Greek sites (http://www.stoa.org/metis/), or those depicted at the "Virtual Callanish" site. However, it is their use in representing landscapes that forms the focus of this discussion.

Although the number of studies presenting the technology in research are limited, those that exist would advocate two main advantages of the approach. Firstly, that the method offers a better objectified and situated portrayal of the landscape than any other currently available means.

Secondly, the combination of its situatedness and inherent interactivity enables its use as a heuristic tool, for use in research or education, in which the user is enabled to interrogate the data for themselves, and formulate their own experiences and meanings (Cummings 2000a, 2000b, Jeffrey 2001, Larkman 2000, Trick 2004). Implicit in these studies is the sense that PVR provides a better *sense of place* than other means of representation.

5.4.2 – A Critical Approach to Representing Landscape with PVR

Although some research based uses of the technique are starting to appear in the literature (Gidlow 2002, Jeffrey2001, Larkman 2000, Trick 2004), very few explore a critical approach to the role of PVR in landscape studies over and above the somewhat implicit indications that they are generally a good thing or worthwhile. The most comprehensive consideration and critique of the use of PVR in landscape studies has been provided by Vicki Cummings, in two complementary papers looking at the siting of chambered tombs in the Hebrides (2000a, 2000b). Cummings approaches the technology from the perspective of trying to find suitable ways of representing phenomenological observations made in the field. The general problems of landscape representation have been introduced in Chapter 1 (section 1.2.4), and in particular, how these problems have detracted from previous phenomenological studies (Brück 2005, section 1.2.3). These problems are elaborated below.

Cummings argues that previous attempts to convey subtle and subjective experiences of landscape have largely been inadequate. Traditionally, discussions of landscape have been presented in a rather dry, passive academic voice. These are often accompanied by a limited number of black and white photographs and archaeological plans, even when the specific intention of the work has been to discuss embodied and subjective experiences (e.g. Barrett 1994).

Tilley's seminal work, *A Phenomenology of Landscape* is another example (1994). After some extensive discussion of landscape phenomenology, Tilley provides detailed accounts of his subjective observations about the settings and locations of a number of monuments in Wales, and along the Dorset cursus. These accounts are mediated via lengthy textual descriptions of the surrounding landscape, accompanied by a number of photographs. Although Tilley's enthusiasm for the monuments and landscapes he describes is obvious, the overall project does not seem to meet its stated aims, with Cummings stating that "Although this represents a timely and useful contribution to work on landscape, the presentation of these concepts in the format of a printed book fails to adequately convey either a sense of place, or Tilley's own experience of his journey through the landscape", and that "The rectangular, monochrome, photographs provide the reader with a rather abstracted perspective" (2000a: 15).

Cummings's frustration with this means of representing landscape also comes from her own work, in analysing the landscape settings of Neolithic chambered tombs on South Uist (ibid). Field observations conducted at these sites revealed what appeared to be common trends in their locations – many were seemingly located to emphasise views of inland lochs and mountains to the east, but to obscure views of the sea and coastline to the west. From certain positions, the form of the monuments themselves served to obstruct part of the "natural" viewshed, as in the example from Tideslow presented in Chapter 6. When attempting to document these observations using the traditional means, much of the experience of the landscape could not be conveyed, and the different subjective experiences of the three fieldworkers involved was lost. In addition, they wanted to provide a means of enabling those reading their results to interpret the data for themselves. In effect then there appears to be a dichotomy between the demands of academic practice to disseminate the results of such research in abstracted formats such as maps and static images, whilst simultaneously trying to convey these very subjective observations and experiences (Cummings et al 2002).

An obvious staring point would be the use of photography, but in its traditional site based approach, it can only represent a partial view of the monument in its landscape setting. Her initial attempts to negotiate this problem were of a purely analogue format – by producing panoramic line drawings of the landscape around the monuments, in a manner similar to those used in guide books a generation earlier (Wainwright 1960 in Cummings 2000a).

For Cummings this approach has several advantages. Firstly, the panoramic nature of the image allows the reader to see a representation of the complete landscape around a monument, including the apparent emphasis of the views towards the mountains, and the obstruction of the view towards the sea, created by the monument itself (in the case of Reineval). Secondly, she suggests that such images allow the reader to explore them "in their own time", and that this allows a greater sense of "spontaneity" of experience (ibid: 16). Finally, from a more pragmatic perspective, these illustrations can easily be printed, and combining several on a page allows rapid comparison between a number of monuments. This approach has been quite successfully deployed in more recent work on the chambered tombs of Orkney, and the Black Mountains in Wales (Cummings 2002, Cummings et al 2002)

Like any representations however, they have their disadvantages. The drawings do little to convey any true sense of scale, or distance to the near or far horizons. The images are also static, and like any drawing, are the product of a subjective decision by the artist of what to include and what to leave out. As with the map or plan view perspective, they are another way of presenting a view of the landscape not attainable in reality.

Many of these problems in adequately depicting landscapes are an artefact of traditional printed publications, where the number of illustrations (especially colour photographs) that can be reproduced are limited. This is a limitation greatly alleviated by publishing on the Web. As well as freedom from the limitation of reproducing images, the hypertext format also allows a multivocality of description (Hodder 1999), and the inclusion of new media representations simply not possible in traditional publishing. Given the ontological and epistemological context of the need to effectively represent landscapes to a wider audience, and the representational affordances offered by new digital media and the Web, Cummings's decision to explore the use of

PVR was an obvious logical progression. The results of this exploration are published in the appropriate web based format offered by Internet Archaeology, with the resulting panoramas being available for interpretation by the reader (Cummings 2000b).

5.4.3 – Recent Case Studies

Recent work by a number of other authors has also sought to embed the use of PVR within a context that is broadly research based rather than purely presentational.

For Stephen Trick, the technique allows a means of recording viewsheds from monuments, and that this provides both an alternative and a *control* to those derived from GIS based studies, the latter of which are the main focus of his discussion (Trick 2004). As well as providing a form of ground-truthing to GIS bases analyses, he asserts that the format "can offer a much more interactive conception of landscape than the selected viewpoints offered through conventional means" (ibid: 9.0). Four panoramas from different tell sites are provided for the reader to explore.

Brian Larkman chose to explore the use of QuickTime VR as a means of recording the settings of several rock art panels in Yorkshire and Northumberland (2000). He notes the importance of seeing rock art and other monuments in their landscape context, but that this is not always possible due to reasons of cost, distance or access rights. This has important implications for both research and teaching. He suggests that PVR methods represent the best possible compromise between attaining interactivity of representation, against cost and time. Rock art panels in Northumberland and Yorkshire are particularly appropriate subjects for this representation, as both areas have been discussed extensively in recent literature, especially in terms of their landscape settings and intervisibility (Bradley 1991. 1997). Although not providing a full freedom of movement, Larkman suggests that the interlinking of nodes should however enable the user/reader to create a "mental map" of the study areas, and these examples are provided the reader to investigate for themselves. Although not fully immersive, their photographic nature does enable a very high degree of detail to be represented compared to that possible using a VRML model of the same area. One interesting development of the method exploited by Larkman is that in the QTVR Authoring Studio, it is possible to open and edit the panoramic "stitched" image prior to incorporation into the final PVR representation. This enables it to be annotated to illustrate important landscape features not easily seen, or in Larkman's case, apply a somewhat subjective treatment of the image of Roughting Linn to create a "shamanic vision". The use of PVR to document rock art panels in South Africa has also more recently been discussed by Gidlow (2002), and Meister and Asmus (2004).

Stuart Jeffrey's use of the technique focuses on the reconstruction of Medieval stone crosses, and incorporation into their original landscape settings, by a combination of photogrammetric techniques with panoramic photographs (2001). The modelling of the form of the stone crosses using photogrammetric techniques works very successfully for Jeffrey, but he argues solid modelling works less well for the broader landscape. Apart from the general lack of acceptable detail in such landscape models, he sees the absence of a realistic horizon in many such models as particularly problematic, citing Ingold's work on the importance of the horizon in defining a sense of place (Ingold 1997). Panoramic photographs on the other hand enable photo-realistic levels of detail, and an accurate depiction of the actual horizon, and so Jeffrey considers this approach to be better.

Two-dimensional images of the stone crosses can be produced from the modelling software, and these can be inserted into the landscape panorama, to depict the crosses in their original landscape settings. This is not ideal however, so instead he used a hybrid between both methodologies – using a three-dimensional modelling package he was able to create a cylinder around his reconstructed cross, and "map" a panoramic landscape image to the inside of the cylinder. This can then be rendered as an "object movie", in which it can be rotated along with its photo-realistic background. As a technique, this seems to be appropriate for items of a certain scale that cannot be seen in their original locations, as is often the case with Medieval and Saxon crosses.

The Perseus Projects, as described by Thomas Milbank, uses PVR as part of a range of approaches for making three-dimensional images available on the web, alongside static photographs, VRML models and CAD drawings (2003). As well as the use of panoramas and rotateable object type representations, he also documents some of the other more interactive capabilities of the QuickTime format, and how these can be integrated along with supplementary text and images via the Web. This is one of the only examples where the use of PVR models has been described in conjunction with other types of VR models. Unfortunately, the project is not in the public domain, and so it is not possible to comment further on the results and implications of this.

Several authors have also discussed the use of the technology in conserving archaeological landscapes. For Louise Krasniewicz, it is the conservation of primary research data, including the visual appearance of a site in its landscape context, that should be an important goal for virtual reality representations in archaeology, rather than the concentration of effort into producing idealised reconstructions. This is of particular importance in archaeology, where the technique of excavation destroys at least some of the primary data it seeks to collect. Krasniewicz also suggests PVR images could be of real value in allowing archaeologists to virtually "re-visit" monuments during the post-excavation and writing up phases of field research (Krasniewicz 2000). Michael Anderson has used PVR to construct a database of panoramas of Regio VI at Pompeii, which is a region of the city that has neither been extensively documented or conserved, and is becoming increasingly dilapidated (Anderson 2003). In extreme cases, the results of human activity result not only to damage and destruction of individual monuments, but to their surrounding environments. An example of how PVR can be used to preserve a record of such environments under threat, in this case from quarrying, is shown in Chapter 6.

Perhaps the most directly applicable example of the use of PVR to this study has been that of Exon et al, as part of their *Stonehenge Landscapes* project (2000). Using the PanoraMap approach outlined in 5.4.1 (Dykes 2002), Exon et al have interactively linked PVR representations to viewshed maps from a number of monuments around Stonehenge. This technique is explored further in three of the case studies presented in Chapter 6, as well as in one section of the "Exploring Arbor Low" resource presented in Chapter 7. As with most of the studies described above, these panoramas are not discussed in any great detail themselves.

5.5 Three Dimensional Solid Models

The rest of this chapter will focus on the second major category of VR representations presented in this study – those of three-dimensional solid models. It is this form of representation that conforms more to most people's common conception of the term Virtual Reality.

3D models are largely use to represent specific monuments, although the methodologies employed can also be used to represent landscapes (e.g. Roughley Carnac). Typically these models are constructed using Computer Aided Design (CAD) orthree-dimensional drawing and animation packages, e.g. Discrete's "3D Studio Max", more widely used for photo-realistic architectural representations (Holloway 2000). These packages provide the functionality for creating three-dimensional environments, including the ability to "texture map" photographic images onto the surfaces of objects, and create complex animations. Importantly they also have the ability to export the models into a format suitable for delivery, such as Virtual Reality Modelling Language (VRML).

VRML has become a de facto standard for many applications, partly because it can be delivered via the web using freely available "plug-ins" – software that extends the functionality of the web browser beyond basic text and still images (Earl 1999, Gillings and Goodrick 1996, Goodrick 1999, Goodrick and Harding 2000). When viewed within a web browser, such models are freely navigable, allowing the viewer move around the scene in anyway they wish, enabling an emulation of an embodied first person experience. Since its first inception, the standard has been enhanced to enable the spatial placement of sound, and the ability to add greater levels of interactivity with the models via programming. VRML models of landscapes can usually be created by exporting terrain model data from GIS software e.g. ArcGIS. Although VRML is a *standard* rather than a proprietary solution, it is not without problems (see Goodrick 1999 for a critique of these), and there are alternatives to this. An example is Macromedia's "Shockwave 3D" technology, which can also be deployed using their freely available plug-in. This latter approach is the one adopted in this study (Chapter 7).

5.5.1 – Theoretical Implications of 3D Modelling

Some general criticisms of the use of VR in archaeology have been outlined at the beginning of this chapter (5.3). This section aims to develop these further, with particular emphasis on the use of non-immersive screen based three-dimensional virtual reality techniques and applications, in contrast to the panoramic virtual reality methods discussed above.

As with the early adoption of GIS techniques in the early and mid 1990s, the use of VR in archaeology has proliferated steadily, but seemingly without any real engagement with the subject of VR itself, its epistemology and most importantly, how its use is underpinned by relevant archaeological theory. VR models have been generated and presented to the public, but with little attention to what it means to use this technique, and archaeologists have largely failed to ask, "what does it actually mean to describe something as *virtually* real?" (Gillings 2002: 17).

The failure to engage with this fundamental question must lie in part with the fact that most of the work using VR in archaeology has not been for research, but for presentational purposes. Often these have been for high profile projects, such as English Heritage's "Virtual Stonehenge" (Burton et al 1999), or for many of the monuments portrayed in Forte's "Virtual Archaeology"

(1996). It appears that this presentational trajectory has emphasised the need to create models that are "photo-realistic", and an assumption that via the use of more sophisticated hardware and software, more attention to detail necessarily equates with a "better model". What is not often clear is to what use such models can actually be put, over and above the rendering of "ingenious pictures" (Gillings 2002: 18).

The drive towards producing photo-realistic models results in technological advances that do little to develop methodologies that could be more widely and easily used within the discipline, and for greater interpretative value (Gidlow 2000, Gillings 1999, 2002, Pollard and Gillings 1998). One example of these are the developments in solid modelling of buildings – whilst reconstructing monuments "block by block" (Daniel 1997) may indicate the volume of materials originally used and their cost in economic terms, such monuments are reduced to mere considerations of structural engineering, and any sense of "meaning" in them is lost. The real danger then is that as a technique, VR will become marginalised, and there will be a failure to capitalise on its enormous interpretative potential in the future.

This uncritical adoption of VR within archaeology has been most extensively critiqued in several papers by Mark Gillings (Gillings 1999, 2000, 2002, Gillings and Goodrick 1996, Goodrick and Gillings 2000, Pollard and Gillings 1998, 1999), and in the course of these, he has highlighted the need to address three main questions:

1. What is the theoretical basis of Virtual reality in ontological and epistemological terms
2. In what areas can it be usefully used in archaeology?
3. What methodologies enable this in an accessible and non-specialist manner?

Over and above the technical descriptions of VR as outlined in 5.2 above, Gillings has chosen to characterise VR models in terms of two categories, put forward by the philosopher of science, Noel Gray (Gray 1995). The first of these mutually exclusive categories views VR models in terms of "manufactured deficiencies" (Gillings 1999, 2002, Pollard and Gillings 1998). In this category, models are always seen as inferior to the reality they try to represent. They aim to act as "surrogates" of reality (c.f. Reilly 1991), and their degree of realism is a direct correlate of the amount and quality of detail put into their creation. They are however always somehow imperfect. The second category is that of "manufactured intensity", whereby models are in some sense *more real than real*, or at least where elements of the model have been deliberately intensified, such as dimensions or colours (e.g. Goodrick and Harding 2000).

This second category is a little abstract, and not easy to imagine without some clarification. A related concept to that of manufactured intensity is Baudrillard's notion of "hyperreality", in which absolute reality has been lost from modern society, instead replaced by a world comprised of media portrayals such as advertising. Baudrillard's concept of hyperreality abounds in contemporary culture, in everything from supermarket displays to heritage based theme attractions such as Jorvik, so an illustrative example is helpful at this point. In preparation for the opening ceremony of the Winter Olympics in Calgary in 1988, it was decided to replace the snow that would be seen by viewers watching on television, with sand. The reason for this is that sand apparently looks more like snow on television than real snow, and in addition it is more manageable – sand does not cause awkward reflections in the camera, or get dirty and turn into slush, and can easily raked and repositioned as appropriate between shots. The only "real" opening ceremony was that watched on television by viewers thousands of miles away (Staniszewski 1995: 74 in Gillings 2002). Other examples have been noted from theme parks and heritage displays (Gillings 2002, Rodaway 1994, 1995).

It would seem then that there is a dichotomy between VR that on one hand aims to accurately portray some notion of an objective reality, but is always in some way lacking, and on the other hand a model of reality in which "the only reality at stake is that internal to the model itself" (Gillings 2002: 21).

In constantly ploughing more technological resources into creating ever more "realistic" models, archaeological uses of VR seem to be pursuing the goals of manufactured deficiency, and that the authenticity of such models is defined by "visual approximation of form" (ibid: 22), and they can be tested by comparison to some original objective reality. It is at this point that these attempts run into problems. In many cases, there is no objective reality against which to test these models. Often these models are reconstructions based on incomplete and fragmentary data. They may be reconstructions well founded in current archaeological knowledge, but they are reconstructions nonetheless (Kantner 2000).

Reconstructions are always subjective, and this applies to VR models as much as it does to more conventional forms of illustration (Kantner 2000, Pringle and Moulding, in Gillings Constructs 2000). In addition to the paradox of trying to evaluate the efficacy of a model against a reality that no longer exists, the pursuit if realism throws up a more pragmatic problem. Often when confronted by a virtual model, viewers will ask "how realistic is it?" (Gillings, 1999, 2002). Rather than explore the model in a heuristic way, the viewer will try to evaluate it, and lose sight of any experiential quality the model is attempting to impart (Dovey 1985). Given that these models will always be somehow lacking, their effectiveness may be completely lost.

When the authenticity and realism of VR models is assessed, it is often done in comparison to photographic images rather than real objects, so they are evaluated in terms of photo-realism. This is itself problematic, as photographs themselves are not purely objective, and they have to be "read" (Gillings 2002). Accounts of failed attempts by anthropologists to use photographs to elicit names for wild animals during field studies indicates that our understanding and reading of photographs may be culturally constituted (Barley 1983 in Gillings 2002). The advent and rise in popularity of photography in the early 20th century stimulated much debate about the relationship between the photographic image and the external reality it sought to portray. Photographs presented a new form of reality, which could not be evaluated under prior means. This led philosopher Walter Benjamin to conclude that there was no one fixed standard against which all representations could be judged, but instead that these standards were historically contingent and fluid. Photography required its own new set of standards for evaluation, and following from this point, Gillings has suggested that the same is necessary for VR. Irrespective of any philosophical considerations, it will be shown in Chapter 6 that the pragmatic need to compress and reduce digital images for incorporation into PVR models, and the concomitant loss of data, renders the concept of photo-realism as somewhat elastic rather than absolute (see section 6.5).

In considering broader concepts of authenticity, Gillings draws upon the work of philosopher Kimberly Dovey, who has argued that authenticity does not lie in visual concordance, but is instead based within the relationships between people, objects, and the world around them (Dovey 1985). For Dovey, simply mimicking the form of an object does not create meaning, because the meaning inferred from the form of an object is based in the object's authenticity. This is quite an elusive concept. Authenticity requires some other depth of experience other than simple visual concordance. A good example might be in the case of a reproduction of a famous piece of fine art – although paintings can be reproduced with incredible accuracy, an authentic experience of a work like the Mona Lisa carries with it travelling to Paris, going to the Louvre, and queuing up amongst the crowds to see the original, framed in its full socio-cultural context.

The concept of embodiment within a virtual model also requires some consideration. Penny has questioned how VR worlds might appear if they were invented by another culture, with a different attitude to the body (Penny 1993 in Gillings 2000). Although VR approaches enable us to adopt an embodied view within a data set, it could be argued that this embodied view is simply a male western academic one. If the concept of embodiment is culturally specific, this has significant implications for attempts to recreate the experiences of people in prehistory. A similar point has also been made by Brück, who has criticised Tilley's *Phenomenology* for assuming "the body to be a transhistorical entity" (1998: 26 c.f. Tilley 1994).

Taking these arguments together, it would appear that the endless pursuit of the Holy Grail of photo-realism is ultimately flawed, and that "the critical point to emphasise is that VR representations, however stunning and detailed their appearance, can never be wholly authentic" (Gillings 2002: 27). Once this has been acknowledged, rather than endlessly seeking to narrow this gap of manufactured deficiency, archaeologists should face up to the manufactured intensity and hyperreality of such models, and put them to uses that have more interpretative value. Although there is nothing wrong with producing photo-realistic representations *per se*, it is not necessarily the most useful deployment of the technology in archaeology. Rather than be used for creating reconstructions, Barcelo has asserted that the real benefits of using VR in archaeology are to provide the means to "a "manipulation" of an archaeological interpretation", and that via meaningful interactivity, a VR model should "allow people to understand the structure or behaviour of the entity, and to provide a convenient vehicle for "experimentation" with and prediction of the effects of inputs or changes to the model" (Barcelo 2000: 9). The static nature of many photo-realistic models also renders them as inappropriate for use in educational contexts (Rousseau and Drettakis 2003).

Whilst there are real world situations where authenticity as mediated by high levels of visual concordance is absolutely essential, such as simulated surgical or flight training, these levels of visual concordance in archaeology are not always necessary, and much interpretative value can be derived without going to such great lengths. A good example of this is the reconstruction of the tower at Peel Gap on Hadrian's Wall (Gillings and Goodrick 1996). In this study, a look out tower in a seemingly anomalous position along Hadrian's Wall was created using VRML, with the specific intention of determining what could be seen from its location. This was more than adequately achieved creating a simplistic model using rudimentary primitives (simple shapes) and blocky textures. There was no need to reconstruct the tower block by block, or adorn it with photo-realistic textures, and rather than define this use of VR as the creation of some kind of surrogate, its meaning was dictated by its purpose and use (ibid).

Rather than adhere to any rigid and restrictive theoretical approach to using VR, Gillings has chosen to employ an inclusive reinterpretation of the concept of mimesis to frame further work. Rather than seeing mimesis as simple mimicry, his broader or enriched view of the concept is one in which a representation does not simply copy the appearance of something, but rather is "to provoke in viewers the feelings provoked in them by the thing copied" (Bailey 1998 in Gillings 2002: 30).

Having developed a useable theoretical and practical understanding of what VR actually is, it is possible to consider Gillings's second main point, which is to consider to what uses non photo-realistic VR models can be productively put in archaeological research. To do this we need to look at another form of archaeological representation – the plan, and the limitations of this format in fully understanding megalithic monuments such as Avebury, Stonehenge, or Arbor Low.

5.5.2 - Maps, Plans and Embodiment

The convention of the archaeological plan is possibly the most widely used form of representation within the entire discipline. But, as introduced in Chapter 1, plans and maps are a very particular way of presenting information, and relying on them entirely as sources of information restricts our understanding of monuments and the articulation of space within them. Part of the problems with maps and plans can be seen to have roots amongst the broader problems with the depiction of landscapes in general (Thomas 1993).

Thomas has described how the primacy of vision encourages an empirical view of science, in which the rendering of something as visible also facilitates its being understood (ibid). It also aspires towards "totalisation" – the ability to see everything from a situated point. Thomas referred to Foucault's view of "totalised history", in which the historical past is viewed as some completed self contained project – a perspective we can only grasp by putting ourselves outside of the historical process, which of course we are not. Similarly, forms of archaeological representation such as a distribution map or plan equally attempt to provide a detached and totalised view. The phenomenological approach rejects this conception of such a totalised view, instead asserting that rather than living in a world comprised simply of objects, we dwell in a world of significance and meaning (Heidegger 1962 in Thomas 1993, Sokolowski 2000). Most importantly for archaeologists is the notion that "we cannot simply draw out a mapping of structures and boundaries and hope that their simultaneous spatial relationships will inform us about past people" (Thomas 1993: 28).

Whilst many of these observations by Thomas were framed in reference to depiction of landscapes, they can also be applied more specifically to monuments themselves, by deconstruction of the concept of the archaeological plan. This has been clearly articulated by John Barrett, in his discussions of Avebury (Barrett 1994).

Barrett opens his critique of the archaeologist's plan by contrasting the experience of Avebury between that of a "visitor" to the monument, with that of an archaeologist, viewing it remotely via the convention of the plan. When a visitor encounters Avebury, their experience can be described as "partial and erratic" (ibid: 12) – they arrive at the monument and walk around it in their own time, discovering the monument bit by bit, and constructing their own subjective relationship between the various elements as they go. They certainly never experience the monument "all at once". Experiencing the monument via the archaeological plan is very different. Here there is no sense of revelation, rather that the monument has become compressed into one immediate experience of time and place, being "observed at a single moment" (ibid: 12). The plan provides the archaeologist with the kind of detached and totalised view of history discussed by Thomas above (Thomas 1993). Whilst the convention of the plan is arguably pragmatic and convenient for those who understand it, it comes at the expense of understanding such a monument's ability to structure space and experience for those who may have been present in prehistory. Such understanding can only be resolved at the scale of the human body, as it moves around the monument in relationship to the structural elements that comprise it, and to the presence of others. This is not just a theoretical point – research in cognitive psychology has demonstrated there are significant differences in how space is conceived between those who only experience a place from a map perspective, compared to a fully embodied one (Pollard and Gillings 1998). Interestingly, prior to Stukeley's first plan of Avebury, many of the villagers were never aware that the stones were arranged in a circular format (ibid).

The significance of past events at Avebury or other similar monuments would be afforded by the architectural configurations of stones and earthworks, but equally importantly would only become realised by the movement of those attending events there, and it is the combination of these that would structure ritual proceedings that may have taken place, creating Barrett's "regionalisation" of space (Barrett 1994: 18). In the case of Avebury, there are real architectural devices that can only be understood in terms of a mobile and embodied experience (Thomas 1993), and these are simply not "present in the void of the physical plan" (Barrett 1994: 19). An additional problem is that it is very easy to subconsciously slip from a "plan view" of a monument to a "planned view". This goes contra to Barrett's assertion that the monument complex around Avebury (including the Avenue and the Sanctuary) should be viewed as a series of piecemeal projects conducted at various locales, never conceived as a single planned entity, instead constructed by builders who "rarely glimpsed at the totality of creation" (ibid: 14).

Taking and embodied phenomenological view of Avebury reveals an interesting and subtle articulation and grading of space via monumental architecture. Most obvious are the enormous banks and ditches, particularly at the southern entrance, where it meets with Kennet Avenue, itself comprised of a dogleg shaped line of opposing standing stones. The stones of the outer circle are notably larger near this southern entrance, and would have obscured much of the view to the spaces within. In particular they would have restricted the view to the space within the two inner stone circles. The northern one of these contains the "cove", and enormous seven metre high "obelisk". The three-sided nature of the cove would obscure views to within it from the southern entrance, and views of the southern entrance would be obscured from either the cove or the obelisk. The area within the cove would be the most secluded within the entire monument, possibly analogous with burial chambers of megalithic tombs (Burl 1990). Although these features present barriers to vision to and from certain parts of the monument, they would not be impermeable to bodily movement, but instead might guide and structure the nature of ritual processional activity. Whilst monuments like Avebury can include more participants at rituals than megalithic tombs by virtue of their size, they also have the potential to create greater divisions amongst these participants via their internal architecture (Bradley 1998, Thomas 1993).

These observations about Avebury and the surrounding monument complex made by Barrett and Thomas are not simply ones of architectural curiosity. What is of real interpretative significance is that these mechanisms to structure ritual proceedings would also have real social connotations, possibly reflecting an emergent stratification amongst those who attended such rituals, and realised at the scale of the human body through movement. This starts to provide something of a mandate for the use of VR to explore such monuments.

The archaeological plan, no matter how accurately recorded and drawn, is an inherently inauthentic experience, because whilst it may have perfect concordance with geometric reality, it contains nothing of the depth of experience that an embodied encounter with a monument provides. It is this embodied experience through which senses of revelation and partitioning of space can be resolved. The process of this resolution is inherently dynamic – it requires movement through and within to exist. The realisation of these subtle architectural configurations and relationships is an ontology that exists beyond the depiction of space in map or plan view. Most importantly for the use of VR, we can only then hope to uncover these subtle forms of discourse by exploring the monument in a situated and embodied way (Barrett 1984, Pollard and Gillings 1998, Thomas 1993). Despite some of the assumptions about embodiment in virtual spaces, VR can take us towards such an embodiment. This provides a very real and valid context for the use of VR at Arbor Low. Whilst Avebury and Arbor Low are obviously different monuments, the approaches to looking at them can be very similar. Similar enough to provide a context for the use of VR that is demonstrably situated within contemporary archaeological thought.

5.6 - Uses of Virtual Reality in Archaeological Research

Before going on to look at the final case study presented in this thesis, it is useful to consider three other examples of how VR has been used to explore spaces within archaeological monuments for reasons of research rather than presentation. These have been selected because of the theoretical and methodological approaches employed, and because they focus on British later prehistoric ceremonial monuments.

5.6.1 - Negotiating Avebury

As well as providing an archaeological mandate for the use of VR at Arbor Low, the above critique also provides the necessary context for the first of these examples, the "Negotiating Avebury" project. This is an ongoing and multi-faceted project, conducted between Mark Gillings, Josh Pollard and David Wheatley (Pollard and Gillings 1998, Earl and Wheatley 2002). The project was initially stimulated by a perceived need to re-examine Avebury in the light of recent interest, and the theoretical advances described above. In the absence of a likely programme of extensive fieldwork, the project has sought to use VR and GIS techniques to provide an embodied and reflexive framework in which particular aspects of the monument can be further investigated.

A major aspect of this study is the creation of comprehensive VR models of the monument, using non-destructive techniques of survey and photogrammetry, the latter of which is being used to construct detailed models of the individual stones. In doing so, this goes some way towards establishing an accessible and non-specialised methodology for the creation of virtual models for use within archaeological research – Gillings's third main question to be addressed in establishing a robust framework for the use of VR within the discipline. Importantly, the project aims not just to create one "Virtual Avebury", but a series of "Virtual Aveburys", allowing a multiplicity of views of the monument. For example, in addition to a model of the monument as it appears today,.a model is being created with an alternative visualisation of the relationship between the Kennet Avenue and the southern entrance, in order to explore different possibilities for vision and movement that this would imply (Earl and Wheatley 2002, Goodrick and Gillings 2000). Other possible Aveburys are being produced, that emphasise concepts of inclusion and exclusion, as well as another that aims to portray an Avebury of the idealised Antiquarian imagination (ibid). Recent developments in the project have addressed issues such as the elemental nature of the stones, and the cultural biographies of the stones themselves. These include the implications of the materiality of the stones and their implied symbolic "gathering" of the ancestors, as well as their continued biographies as they enter the world of cyberspace (Gillings and Pollard 1999).

Most importantly for other practitioners, the Negotiating Avebury project represents the most comprehensive theoretical and methodological exploration of the use of VR in archaeology published to date. Although the methodology employed is not appropriate for all contexts, the study provides a robust theoretical framework within which to situate the use of VR in the exploration of other monuments, as at Arbor Low.

5.6.2 - Thornborough

Recent work by Goodrick and Harding has used VRML to produce a model of the monument complex at Thornborough, in North Yorkshire (Goodrick and Harding 2000). This complex is comprised of three almost identical henges, equally spaced apart, a cursus (underneath the central henge), and a double pit alignment running alongside the southern most henge. In seeking to investigate the possibility of an astronomical orientation for the complex, a model was created, focussing specifically on the orientation of the double pit alignment. The model was created using a DEM exported from the ARC/INFO GIS environment, to provide a ground plane, onto which timber upright posts were added corresponding to the locations of the pits, as these had been demonstrated to be postholes.

Using an astronomical mapping program (SkyMap), an image of the night sky was generated for the Late Neolithic and Early Bronze Age, and this was draped over a hemispherical dome to simulate the night sky over the pit alignment. Merging the data together and creating a final composite model in VRML enabled a freely navigable VR world in which it is possible to explore the timber avenue in an embodied sense. In addition to the interesting observation about possible alignments with Orion's Belt in prehistory, what is perhaps most important about this study was the decision to use simple primitives to depict the timber avenue. Rather than make any attempt to produce a photo-realistic reconstruction of the site, these were deliberately "garishly coloured so as to emphasise their abstraction" (ibid: 116), and the inherent hyperreality of the model was made explicit. Attempts at photo-realism would have added nothing to the model apart from time, cost, and hardware requirements.

Preliminary work on creating a virtual reconstruction at the Arminghall henge, in Norfolk, has also been recently reported by Beex and Peterson (2004). Their discussions of this so far however have mainly been methodological rather than interpretative (ibid).

5.6.3 - Visualising Danebury

The enormous Iron Age hillfort at Danebury was the subject of Graeme Earl's reconstruction work (1999). This site has been extensively excavated, revealing a complex history of re-working of features, specifically around the entrance at the eastern end. Using a range of data, from excavations and site visits, Earl constructed a series of VRML models of the entrance feature, each one representing different phases of alteration. These models were created to try and identify how the roles of the banks and ditches defined enclosed spaces within this entrance, and how these changed over time.

Of particular importance to this study was the evaluation of supposed "defensive" function of this elaborate eastern entrance. Whilst the defensive nature of hillforts has dominated accounts of these monuments, recent authors have suggested that this apparent defensive appearance may be the by-product of more symbolic purposes. Investigation of the models rather suggested that the earthworks seemed to emphasise the creation of liminal spaces, rather than perform any real defensive function. The elaboration of these earthworks over time exhibits continuity of these more symbolic functions, possibly serving to provide differential views to the hypothesised central shrine. Significantly for this study, Earl decided to concentrate efforts in producing a range of "Virtual Daneburys" rather than a single photo-realistic one, and that the articulation of space within the different phases is far more apparent from the virtual models than in plan view.

5.7 Discussion and Conclusion

Virtual Reality can be seen to have had a similar trajectory of use within archaeology as GIS, and coincidentally this has taken place over a broadly similar timescale. Neither technique is theoretically neutral, and early adopters of either technology can be criticised for naively overlooking this fact. Unlike GIS however, where these early "sins of omission" have been performed in research contexts (Gaffney et al 1996: 136), there still appears to be a general absence of relevant research applications of VR in archaeology with which to sharpen the epistemological knife (Gillings 2002, Goodrick and Earl 2004).

It is interesting to note that VR has sought to legitimise itself by referring to a previous form of media, in its goal of attaining photo-realism. This phenomenon is not constrained to VR. In their theory of *remediation*, Bolter and Grusin have suggested that historically *all* new forms of media have referred back to previous forms of representation in order to substantiate their claims of superiority and novelty (1999). With this in mind, it may also be instructive to note that the word *panorama* itself was invented to describe a form of landscape painting in the eighteenth century (Krasniewicz 2000). Panoramic paintings became popular at this time as a means of depicting remote and exotic travel locations, including archaeological landscapes, almost as an analogue precursor to VR. Perhaps the use of PVR representations to depict archaeological landscapes and monuments in the present is simply a remediation of this earlier practice.

Many of the practical limitations and problems with creating PVRs reported by Cummings (2000a) and Anderson (2003) have also been encountered in this study, so will be considered in the context of the case studies presented in the following chapter.

Returning to Gillings's third question, outlined in 5.5.1 above, easy and accessible means of producing VR models are still elusive. 3D modelling software packages are typically quite complex to use, and this has been the case in this study (see also Chapter 8). They are also expensive, and even with a heavily discounted educational price, a package like 3D Studio Max still costs in the region of £600, although this price tag covers areas of functionality *way* in excess of what has been required to produce the models considered in this study. Although VRML is a standard, a modelling package is still required to produce models in it, and the kind of manual editing suggested by Goodrick and Harding would be out of reach to many (2000: 117)

Importantly, as with GIS, the use of VR in archaeology has now moved into a post-critical phase, even if there are still unresolved theoretical and methodological issues. It is with this in mind that the PVR and 3D models produced in this study are considered next, in the following two chapters (6 and 7).

Chapter 6 – Panoramic Virtual Reality (PVR) Case Studies

6.1 Introduction

The aim of this Chapter is to present five groups of case studies demonstrating the use of PVR representations to depict monuments and their wider landscape settings. The general principles underlying the use of this technology has been discussed in Chapter 5 (5.4). The roles of PVR within the aims of this thesis (1.4) are broadly fourfold.

Firstly, PVR enables the representation of monuments within their wider landscape context, and this is important for resolving different spatial scales of experience (Bender 2002, 2006, Edmonds 1999a). In doing so they occupy an intermediary position between the regional scale of analysis provided by the GIS based viewshed study in Chapter 4, and the close-grained experience of monumental architecture as explored in Chapter7.

Secondly, as discussed in Chapter 3, by default the results of viewshed analysis, as with other forms of GIS based studies, tend to be displayed using the interface of the map. Generally problematic, this is particularly inappropriate for representing what is supposed to be an assessment of human experience. In reality, viewshed phenomena would be experienced in a situated manner, with reference to the scale of the human body (Barrett 1994, Thomas 1993, Tilley 1994, Wheatley and Gillings 2000). It is argued that the use of PVR can go some way to representing this experience of viewsheds (Trick 2004).

Thirdly, following from the above, combining PVR representations of monuments with their viewshed data enables the exploration of possible synergies between the two technologies. This has been pursued via a similar manner to that of Exon et al (2000). In this approach, the PVR of the monument is linked to a viewshed map of the same locale, and a pointer in the viewshed map dynamically updates its orientation to reflect the pan angle in the PVR. This form of representation is described in this study as an *embodied viewshed.*

Finally, although the examples presented below are mainly done so from a research perspective, following the broader philosophy of this thesis it is argued that they could also be used as resources for teaching. In the case of the embodied viewshed examples, these could be used to teach *about* GIS, and some of the problems encountered when using the technology, and/or they could be used to teach *with* GIS, using the technology to learn about the landscape settings of monuments (Johnson 2002, Sui 1995).

As discussed in the previous chapter (5), several common themes emerge when looking to critique the use of PVR in archaeology. These relate to procedural and methodological issues regarding procuring images in the field, the restricted nature of the interaction with the images, and problems with the images themselves. There are also broader theoretical issues. As all these problems have also been encountered during the progress of this study, they will be discussed together, after the case studies have been presented below.

6.1.1 Methodology

The panoramas presented below were all created using Apple's QuickTime VR Authoring Studio. This package (now somewhat dated) facilitates the creation of individual panoramas from still images, via a process known as stitching. Individual panoramas (or nodes), can then be interlinked, allowing navigation between them. The linking of the panoramas and the plans and viewshed data shown below was achieved using MapSaVR, from Kaidan (http://www.kaidan.com/products/sqmapsavr.html).

6.2 The Case Studies

The case studies are located on the first CD included in this thesis, labelled "Chapter 6 – PVR Case Studies". After inserting the CD, please open the page called index.html. Each of the panoramas described below can be accessed following the appropriate links, which are named according the sections below (Figure 6.1). If accessing these pages via Internet Explorer, it will be necessary to click once on each panorama to make them active. It may also be worth viewing the pages in "full screen" mode, which can be activated in Internet Explorer by pressing the F11 key.

6.2.1 West Kennet Long Barrow

Whether used purely for presentation, or as an aid to research, most uses of PVR state either implicitly or explicitly that the technology can convey more of a "sense of place" than any other means. This claim is impossible to substantiate in the written word alone, and can only really be tested on a subjective and personal basis, by reference to a representation of a site or landscape that one has already visited in person. The first example illustrates several points. Firstly it serves as a general illustration of the techniques deployed in the subsequent examples. Secondly, by choosing an example of such a well known site, it is hoped that the reader can test the usefulness of the representations for themselves, in reference to a monument that they are perhaps more likely to have visited than some of the Peak District examples that follow. Finally, and perhaps most importantly, most of the examples discussed in this study have addressed either the landscape settings of monuments, or how large ceremonial monuments such as Avebury cannot be understood simply by looking at an archaeological plan. The latter point however can also be extended to the architectural space within a burial mound (Thomas 1990). Rather than considering tombs as a vantage point from which to look out over the surrounding landscape, this first example provides an opportunity to actually look *inside* such a monument, conveying the articulation of space within.

The high profile nature of the site also serves to demonstrate how a PVR model could be used as teaching aid – many if not all students of British prehistory will have seen plans and/or photographs of the site, but opportunities to visit the may be limited or absent. Whilst there can be no true replacement for a real visit, it is argued that this presentational format enables students to engage with the monument in a manner not possible via traditional publishing. Where site visits are possible, giving students access to such a model could be used as preparation prior to a field trip, and/or for debriefing and revision purposes after, so that students can maximise the benefit of this logistically expensive experience (Kent el al 1997, Holtorff 2001).

The first representation of West Kennet (Example 1, Figure 6.2) shows the basic features of a PVR model. In this case, being inherently interactive, the image is inactive until some user intervention takes place. The image can be navigated in the following ways, as shown in Table 6.1 below

Pan image to left or right	Click and hold down left mouse button over image and drag to left or right
Tilt image up or down	Click and hold down left mouse button over image and drag up or down
Zoom image in or out	Press the SHIFT key to zoom in, CTRL key to zoom out (cursor needs to be over image)
Jump to next node	Find a part of the image where the cursor turns into a ⇧ image, and click left mouse button

Table 6.1 – PVR navigation

This model is comprised of four interlinked nodes. The first node, taken outside the monument allows the user to pan left and right to see the façade of the monument, although limited to a 180-degree view. Silbury Hill can be seen to the right of the kerbing (as noted by Devereux 1991), and this view corresponds to what would have been the "performative zone" of the monument after the chambers had become blocked (Barrett 1994, Thomas 1993, 1999). Clicking on the giant lozenge stone of the façade links trough to the next node, just inside the entrance to the barrow, looking down the passage towards the furthermost western chamber. This node allows full 360-degree rotation, as do the next two nodes further inside the monument. Clicking down into the passage links to the next node, located in the passage between Piggott's north western and south western chambers. Clicking again into the furthermost chamber links to the final node in the panorama. At this point the reader is recommended to experiment with navigating through the four nodes of the panorama, and is invited to evaluate how well the representation conveys a "sense of place".

The darkness and enclosed nature of the spaces in the passage and chambers becomes quite apparent, and this itself could be a learning outcome in an educational context. Phenomenological accounts of experiences within tombs have suggested that these may have been dramatic or threatening encounters, involving negotiating rotting corpses in semi darkness, and highly charged with ritual practices. These experiences may have been partly structured by encountering different zones of darkness and light (Bradley 1988), and by the use of different coloured stone within the tomb's construction (Jones 1999). Entering the tomb itself may have been a privilege of social order, the distinctions of which were articulated by the architecture of the monument itself (Barrett 1988, 1994, Edmonds 1999a, Thomas 1990, 1999, 2006). Whilst the full significance of this experience would be socially constituted, the PVR representation gives some idea of the physicality of the locale itself.

In the second representation (Example 2), the same panorama has now been linked to a plan view of the monument – in this case Piggott's classic excavation plan from 1962 (Piggott 1962). The actual panorama, now located in the upper right hand side of the image, can be navigated with the mouse in exactly the same way as in the first example (see Figure 6.3). In addition, incorporated into the plan are four red circles, indicating the location of each node. For the currently active node, a yellow arrow indicates the direction in which the virtual visitor is looking, and this is dynamically updated as the panorama is panned. Clicking on the red node markers provides another means of moving between the nodes (although doing this can have an idiosyncratic effect on the viewer's pan angle).

Linking the panorama to the map increases the functionality of the representation in several ways. Firstly, informal feedback from users of panoramic images suggests that there is a real danger of becoming disorientated within these models, especially when comprised of a number of nodes. The specific need to contextualise PVR representations using maps or plans has been noted by Johnson (2002). The sense of spatial orientation provided by the inclusion of the map helps to facilitate this. Secondly, the map itself can provide supplementary information not available in the raw panorama. In this case Piggott's plan indicates the provenance of sherds of Peterborough and Windmill Hill ware from his excavation, as well as providing key structural information about the architecture of the tomb. The same panorama could be linked to other plans, showing for example the differential deposition of various human remains within the different chambers (Thomas and Whittle 1986). Thirdly, the plan enables students to gain some understanding of the differences between the conventions of the archaeological plan in its idealised and abstracted view, and how this translates to what can be observed in the field. Placing the two together in the same image enables a direct side-by-side comparison. In such an educational context, exploration could be activity based as well as purely reflexive. The images are of sufficiently high resolution to facilitate an activity where by students are asked to find some recently deposited red berries in one of the revetment walls by using the panorama, and then locate these on Piggott's plan. The activity itself could provide stimulation for a discussion about the broader role of such monuments as living entities in the present (Bender 1998).

In the final representation of the monument (Example 3), the panorama is linked to an isometric view of the monument in its currently reconstructed form, and is shown on Figure 6.4 (Piggott 1962). As with the plan, the combination of the two enables students to gain some understanding of how isometric representations correspond to what can be observed in the field. The juxtaposition of these two images is interesting in itself, as Piggott's isometric diagram is another example of an attempt to recreate a three dimensional space with a two dimensional image.

6.2.2 Green Low Passage Grave

The next pair of examples come from the Green Low passage grave near Aldwark. This site, discussed earlier in Chapter 4, is one of the four certain Neolithic passage graves of the Peak District. It is also one of the few Neolithic barrows in the Peak to be excavated using relatively modern techniques (Manby 1965).

In the first example (Example 1), the panorama is linked to Manby's 1965 plan of the monument after excavation (see Figure 6.5). As with the previous example at West Kennet, looking at the plan and extant monument together provides an opportunity to investigate how the plan corresponds to what can be observed in the field. In contrast to the previous example, this tomb is in a very different state of preservation, being largely collapsed and ruined, as compared to the extensively restored site at West Kennet. In the default opening view, the panorama is looking towards the tomb, approximately northwards, and despite the state of preservation, it is possible to recognise the mound of the tomb, the façade and kerbing at the front of the tomb, and the partially reconstructed chamber within. Panning the view from this location enables the viewer to experience something of the landscape setting of this tomb. It also enables the viewer to contrast the views experienced looking directly into the tomb, as if witnessing ritual activity around the forecourt area, or away from the tomb, looking towards those who may have gathered in front of it and the landscape beyond. By jumping to the second node, the viewer is placed beyond the other end of the tomb, facing away from it (by default the majority of the panoramas have been designed to "face the direction of travel" when linking between nodes). By panning the panorama 180 degrees from the second node the viewer can look along the axis of the tomb, towards the first node, and towards the striking natural feature of Harborough Rocks on the horizon. When looking in this direction from either node, one of the problems encountered with creating panoramic pictures becomes apparent– that of maintaining even exposure, as the panoramic image is much darker when facing in this direction. This is discussed further in the critique below.

The second example, shown in Figure 6.6, features the same panorama, but linked to the GIS derived viewshed as discussed in Chapter 4 (Example 2). This is the first example of an *embodied viewshed.* In this approach, the viewshed as calculated and displayed in the GIS, as an abstracted view, can also now be experienced in a more situated embodied view, via the panoramic image. As in the example of the linked plan, the pointer on the viewshed map updates its direction as the panorama is panned, allowing an interactive view of how the calculated viewshed looks "on the ground". As discussed in Chapter 4, Green Low has the smallest viewshed of the four passage graves in the Peak. This is quite restricted in the immediate distance, meaning that this is largely obscured in the viewshed map by the node pointer symbol. The location of the second node is virtually at the edge of the viewshed from the tomb itself. The significant effect of localised topography on the viewshed is also now quite apparent, with the viewshed to the north west of the monument being severely truncated by a relatively gentle rise in slope over a distance of only several hundred metres. This contrasts with the more extensive views to the east, over the Grange Valley and Via Gellia.

Looking south from either node, both the horizontal axis of the tomb and the entrance to the passage appear to be orientated towards the natural outcrop of Harborough Rocks on the horizon. This was the location of a now destroyed passage grave, as well as evidence for earlier Mesolithic activity (Barnatt 1996a, Barnatt and Collis 1996, Edmonds and Seaborne 2001). This has some interesting parallels with patterns observed by Roughley, when looking at chambered tombs around Carnac, where she suggests that the axes and entrances of these tombs are aligned to reference the most distant point of the viewshed (Roughley 2001). Although Harborough Rocks is not quite the most distant point in the viewshed of Green Low, it is the most distant point in the viewshed when looking along the axis of the tomb. Those exiting the passage of the tomb would have their view focused on this point, as would observers stood around the location of the second node, looking along the axis of the barrow. It would not be possible to make this observation by looking at either the panorama or viewshed map alone.

A final observation from this second representation regards the effect of vegetation on viewsheds. As noted in Chapter 2, the effect of environmental factors such as past vegetation could have a profound effect on the viewshed from any given point, especially when in close proximity to the viewpoint. This is illustrated quite clearly in this example, where the presence of trees to the immediate south west of the monument obscures the views of the landscape beyond. Comparing the panorama with the viewshed map, the vegetation does indeed present a barrier, which prevents this potential affordance of the tomb's location being realised. Limited molluscan evidence from Manby's excavation suggests that this tomb was in a small clearing, but the extent of this is unknown. Similar evidence has been found at South Street, Avebury (Ashbee et al 1979). Interestingly, Manby also reported that Minninglow could be seen from Green Low, although this is not born out by either the panoramic evidence or that from the GIS derived viewshed. This could either again be due to modern vegetation, or to inaccuracies in the viewshed itself.

6.2.3 Tideslow

The next example shows how the use of PVR can lend additional interpretative value to GIS derived viewshed data, in this case from the Tideslow Great Barrow (introduced in Chapters 3 and 4). This barrow has a long constructional history, being embellished from its earlier Neolithic "closed chamber" type, into the larger and later Neolithic Great Barrow that is seen today (Barnatt 1996a, Barnatt and Collis 1996, Radley and Plant 1971). The viewshed from Tideslow has also been discussed in Chapter 4. This viewshed is extensive in terms of total area and long distances theoretically in view, extending over 20 km south to include the land around Minninglow. By virtue of its topographic setting, the viewshed is also quite panoramic, in contrast to that of Green Low discussed above, or Five Wells below.

One of the criticisms of GIS based visibility studies discussed in Chapter 3, is that they often by default calculate simple undifferentiated viewsheds in all directions from a given point (3.3.3, Wheatley and Gillings 2000). In some cases this suggests the ability to see in all directions, as at Tideslow, although this is misleading as human vision is not panoramic, and requires bodily movement to see in all directions, and all directions cannot be seen simultaneously. The first point of this example is to demonstrate how a panoramic viewshed might be experienced at a monument.

Looking at the panorama in its default opening state (Example 1, Figure 6.7), the embodied viewshed provides very clear view of the landscape to the south, west and east. When panning round to look at the land in view to the north of this point however, the viewshed is obscured by the form of the burial mound itself. Even by turning round in one spot, the panoramic nature of the viewshed cannot be experienced. This obscuring of the landscape demonstrates one way at least how the architecture of the mound can structure one's experience of the experience of the landscape around it (Cummings 2000a). To experience the full panoramic nature of the viewshed for those attending rituals at the monument would then invite movement – not just turning around in one place, but actually walking to another location around the barrow. Put another way, the viewshed of the monument needs "to be understood in the context of movement from place to place" (Thomas 1993: 30). This can be demonstrated by jumping to the other nodes. The two nodes on the north side of the barrow (the two from which the television transmitter and substation are clearly visible) allow a much less obscured view of the monument's viewshed to the north, and also to the east and west. By linking these four nodes together, and experiencing the full viewshed affordance from the monument, it enables in some way the reconstruction of ritual processional activities that may have taken place there (Barrett 1994, Thomas 1993). In summary then, not only does the monument occupy a location that provides an affordance to have a panoramic viewshed, but the form of the monument structures how this viewshed would actually be experienced, requiring movement and possibly some ritual processional activity to experience this viewshed in its totality.

Another criticism of GIS based visibility studies is that by default the viewshed algorithms calculate visibility over an infinite distance – or in real terms, from the viewpoint to the edge of the DTM (Wheatley and Gillings 2000). As well as the potential to create "edge effects" (van Leusen 1999), there is also a danger that the unconstrained analysis can denote areas as being visible that are simply too far away to see with the naked eye, or too distant to be meaningful (Fraser 1983). This may be of specific importance when discussing the potential long distance relationships between these monuments and those who build them, especially if arguing that reciprocity of view between sites was an important factor. Being some 20 km apart, one might question that the inclusion of Minninglow in the Tideslow viewshed is an example of exactly this, and that this result warrants ground-truthing. The second purpose of this example is to document this ground-truthing.

Minninglow Great Barrow is actually almost exactly in the centre of the panorama in its default opening view. On a clear day, this tomb is *clearly* visible on the horizon, its visibility emphasised by the stand of trees growing on top of the mound. Although not clearly visible in the panorama, clicking on the Show Minninglow link to the right of the panorama opens a new window, showing the view of Minninglow taken from this node, before it was reduced in size prior to incorporation into the panorama (see Figure 6.8). The discrepancy between this view, and that in the panorama itself highlights another limitation of the technique – that of image quality. The fact that Minninglow is not visible in the final panorama but is clearly visible in the field *and* the uncompressed image questions the assertion that this technique can provide a fully objectified view of the landscape. The whole concept of photo-realism is also called into question when dealing with digital images that may be compressed or reduced in size for pragmatic reasons, as these techniques invariably resulted in loss of data. This is discussed further in the critique.

The stand of Beech trees on top of Minninglow makes it a very striking and well-known landmark in the Peak District today, and as a result it is also an excellent object of study for verification of visibility studies in the field. It also raises an interesting observation about the effects of vegetation on the visibility of monuments in the landscape. When looking at the image of Minninglow, it is not just the trees on top of the mound that make it so visible, but also the modern plantation that forms a ring just below the apex of the mound, which serves to draw attention to the mound itself. This may have been important in prehistory, if land in the immediate proximity of monuments had been locally cleared, even if much of the wider surrounding landscape was still wooded. The striking contrast between cleared and un-cleared land, along with limestone blocks used for construction would make these monuments highly visible, even at significant distances. The possibility that such localised clearances around monuments existed in prehistory has been mentioned above (6.2.2), and the importance of this has recently been discussed by Cummings and Whittle (2003). The effect of vegetation on the viewshed when in close proximity to the viewpoint is also demonstrated in this example.

Although it has not been quantified using the Higuchi methodology discussed in Chapter 2, qualitatively the viewshed from Tideslow has a good mixture of land in view in all three Higuchi distance classes. Studying how the landforms included in the viewshed map corresponds with what can be seen in the panorama gives a good sense of how these differing distances are actually experienced in a panoramic viewshed. Looking towards Five Wells from the first node demonstrates this well – although the view is continuous in the panorama, the viewshed map indicates that there are large "gaps" on the ground between areas actually in view. The appearance of this would not be obvious by looking at the viewshed map alone, and again combining both images gives a good indication of how these discontinuous "parcels" of viewed land are actually experienced in an embodied view. Equally, the presence of the viewshed map, depicting known points at quantifiable distances from the viewpoint, enables a sense of scale to be introduced to the panorama. It would appear that both viewshed maps and panoramas require some learning of how to be "read".

6.2.4 Five Wells

The Five Wells passage grave has also been discussed to some extent in Chapter 4. It was argued that along with its architectural form which enabled direct and structured access to the remains of the ancestors, its expansive and yet focused viewshed could suggest it played an important integrative function between the monuments and people of this northern part of the White Peak. Also noted in this discussion was that the landscape setting of this monument appeared to structure its viewshed to almost totally restrict its view to the south, yet provide such extensive views to the north, east and west, forming a semi-circular arc oriented on its own axis. This contrasts markedly with that of Tideslow, and the first of the two case studies presented here demonstrates how this viewshed appears from an embodied first person view (Example 1, Figure 6.9).

The first node of the panorama was taken very close to the edge of the immediate viewshed of the tomb – in fact the first point at which the monument becomes visible when walking up the limestone ridge upon which it is located, at an observer height of 6 ft. The default view of this first node looks north over the river Wye. The quite sudden appearance of the tomb at this slight break of slope clearly demonstrates the "false cresting" of its setting, and this phenomenon has been discussed in reference to other Neolithic tombs (Edmonds 1999a, Roughley 2001).

Clicking through to either of the other two nodes places the viewer either side of the tomb's east and west facing passages, with the viewer direction facing south. Panning the view around from either passage entrance clearly demonstrates how the very localised topography of the tomb's setting truncates its viewshed to the south. It also clearly shows how the truncation of this view runs parallel to the axis of the tomb. By facing away from the tomb at either entrance it is possible to get some sense of how the landscape may have appeared to those exiting the inside of monument along either passage. Roughley (2001) has commented on how the orientation of passage graves around Carnac appears to emphasise the most distant points in those monuments' viewsheds, and that these views would be those encountered first when exiting these tombs along their passages. To some extent this can also be seen at Five Wells, with the exit from the eastern passage focussing views towards the Eastern Moors of the region, around Gardom's Edge. The monument's viewshed does however seem to focus more on the land to the immediate north and north west, overlooking the Wye, and this land that may have been amongst the most favourable for grazing in this part of the Peak (Barnatt 1996b, Edmonds and Seaborne 2001). Most striking however about this landscape setting is how the very localised and quite subtle topography to the immediate south of the tomb so effectively obscures its view of the land towards the south. The tomb would only need to be sited some 10 metres or so to the south to have a totally different, and quite panoramic viewshed, affording views both to the north, but also to the south, towards the central zone of the White Peak. This observation has also been noted by Barnatt (ibid: 102-103), and leads to the next example.

It was noted in Chapter 4, that natural formations of limestone at several places in the White Peak create topographic features that act as "boundaries", serving to delineate the viewsheds of certain monuments in one direction or another. One such feature is Longstone Edge, discussed below, and another is the limestone ridge upon which Five Wells is located, near Taddington Moor. It was also noted that the use of Cumulative Viewshed Analysis revealed some interesting palimpsests of intervisibility around these boundaries, again especially around the land in the immediate vicinity of Five Wells. The Tideslow and Minninglow Great Barrows appear to have *almost* totally mutually exclusive viewsheds, although sometimes the viewsheds appear to exhibit very restricted areas that overlap, as at Five Wells.

Although Five Wells itself sits just outside the viewshed of Minninglow, within that of Tideslow, close inspection of the CVA created for all three monuments indicates that there is a very restricted tract of land from which all three monuments are visible If the location of Five Wells was at a highly symbolic boundary between the land in the northern half of the White Peak (broadly within the viewshed of Tideslow), and the land in the central and southern parts of the region (within the viewsheds of Minninglow and Harborough Rocks for example), then a very restricted area of land from which all three were visible may have held enormous significance. Given the uncertainties in accuracy inherent in GIS derived viewsheds, as described in Chapter 2, and the potential significance of these results, the discovery of this phenomenon warrants ground-truthing. This next example (Example 2) documents that ground-truthing.

Because this example is the most complex of those presented, both in terms of the number of nodes and the nature of the phenomenon it is intended to represent, the nodes have been numbered. Because of the importance of accurately ground-truthing this phenomenon, the exact locations of the nodes in this panorama were established with a GPS receiver in the field.

Node 7 is the default starting node for this panorama – the nodes were numbered in the order they were photographed over a number of successive visits to the area. Its default view is looking towards the limestone ridge upon which Five Wells sits, providing some landscape context to the setting of the tomb (Figure 6.10). The false cresting of the tomb's location is again evident, as it cannot be seen from this point. To aid clarity of representation, the locations of Tideslow and Minninglow have been indicated by the letters T and M respectively (Exon et al 2000). Panning the panorama to the east (leftwards) shows the location of Tideslow on the horizon. Panning around the rest of the image at this node also shows the gently undulating topography of the land overlooking the river Wye.

Panning back to the default opening view, and clicking towards the top of the ridge links through to Node 1. This is the same node as the first node discussed in the example above, but this time its default view is towards Five Wells itself, which is now skylined on the horizon. Clicking on the hot spots either side of the tomb links through to the second and third nodes described above (Nodes 2 and 3 on the viewshed map). Important to note here is that in such immediate proximity to the tomb, only Tideslow is visible. When arriving at either of these nodes, the default view is due south, facing the slight upslope that truncates the viewshed to the south. Both Nodes 2 and 3 link to this point, which navigates to Node 4.

By default, Node 4 is now pointing south east, directly towards the central and southern part of the White Peak, with Minninglow visible on the horizon. It is at this point that Five Wells, Tideslow, and Minninglow are now in view, but only over a very restricted area (Figure 6.11). The restricted nature of this phenomenon is clearly demonstrated by navigating to Node 6. By this point Five Wells has disappeared from view, and this node is located within the overlap zone between the Minninglow and Tideslow viewsheds, also quite restricted in area. Node 9 (which can only be navigated to from 6 and 8) is quite literally "south of the border", now being located within the viewshed of Minninglow only.

It should be noted that when choosing the locations for Nodes 4, 6 and 9 in the field, care was taken not to choose locations on the very edges of the various monument's visibility/invisibility, as doing so might prejudice the observations in terms of viewer height. This is important because the fieldworker in this case was significantly taller than that taken as the Neolithic average of 1.65m for males, and 1.57m for females (Roberts and Cox 2003). This is also important in terms of trying to calibrate the observations with the GIS based analysis performed in this study, which assumed an observer height of 1m. Because of this, Nodes 4, 6 and 9 were placed "comfortably within" the zones in which the viewshed phenomena occur.

One of the most subjectively striking experiences when conducting this fieldwork over several occasions were the **very** short distances over which these phenomena operate. The linear distance between the Five Wells eastern entrance and the first appearance of the characteristic trees at Minninglow was in fact only about 10m at an observer height of 6ft. At the same observer height, the total distance from this point walking south before

Five Wells disappears again is approximately another 50m. The very sudden nature of these encounters and experiences is not particularly well conveyed in this representation. This is partly due to how the node locations were chosen (as above), but is also an artefact of how the panoramic image seems to become somewhat flattened, with objects in the near distant seeming relatively further away compared to objects in the middle and far distance. This is another limitation of the technique (or specifically the camera). As with the example at Tideslow, the monuments are far more clearly visible in the field than shown in the panoramas. More detailed views of Tideslow and Minninglow are provided by clicking the appropriate links above the panorama (Figure 6.12). As at Minninglow, recent human activity has conveniently made this monument quite easy to spot in the landscape, in this case by the construction of a television transmitter.

Having created the model as an exercise in ground-proofing, it is also possible to explore its use as a means of reconstructing possible ritual activities around the tomb. Those approaching the tomb from around the Wye Valley might do so by passing nearby to Node 7. As with other tombs, the locale itself may have already held significance running long into the Mesolithic past, and the appearance of the ridge itself may have held deep meaning (Barnatt 1996a, Edmonds 1999a, Edmonds and Seaborne 2001). Ascending the slope and arriving at Node 1, the monument would now be skylined. Turning to face North, there would already be a commanding view of the grazing lands overlooking the Wye Valley, lands perhaps over which tenure was secured by the ancestors. From here up to the tomb itself may have been an important point for viewing rituals taking place at the tomb itself, now skylined in view. The locations of Nodes 2 and 3 may have been the reserve of a restricted few – those who had power and authority to intercede directly with the ancestors. Walking on up to Node 4, the whole experience would change, with the sudden and dramatic revelation of the central zone of the White Peak unfurling beyond. The restricted views from Five Wells itself may have served to heighten this dramatic and subjective sense of revelation. Minninglow, Tideslow, and Five Wells are now all in view. Almost irrespective of any kind of "territorial" relationship between the former two, this would be the place where you could see all. The junction between two worlds. For those journeying further on to the south (Nodes 8 and 9 and beyond), familiar landmarks will have all but disappeared within a few hundred metres. One can only speculate about the level and nature of significance that this could have held for those travelling between these zones. Those travelling from the south to the north would experience a similar sequence of revelations, but in reverse.

6.2.5 Longstone Edge

The final example of PVR presented in this study concerns its use as a means of conserving a monument in a landscape under threat. During 2005 it was discovered that Bleaklow Industries had been illegally quarrying limestone at Backdale Quarry, on Longstone Edge. As part of the operation they had erected a fence, part of which ran right over a scheduled Bronze Age barrow, and the monument became damaged. As compensation they were ordered by the Peak District National Park Authority to pay for an archaeological evaluation of the damage that had been caused, for which ARCUS (The University of Sheffield's excavation unit) were appointed. Not strictly the order in which things should be done, but better than nothing. The excavation was conducted in November 2005, as this Chapter was being written, and given the potential damage to the site and its immediate locale, a decision was made to create a panorama of the site whilst digging was in progress (Figure 6.13).

There is more to the use of this PVR over and above demonstrating its potential as a form of digital conservation (Anderson 2003), as both the site and the location are of importance to this study. It was noted in Chapter 4 that Longstone Edge as a natural feature, creates a significant boundary between viewsheds of monuments to the north and south of this point. This results in a palimpsest of intervisibility running along this reef limestone feature, and as at Five Wells, this phenomenon may have been significant in structuring the experience of this locale in prehistory (Tilley 1994). Also noted was that a relatively recent excavation discovered Neolithic burials under a barrow on Longstone Edge that had previously been classified as Bronze Age, and that even more recently, the same had occurred at Stan Low. This is significant as it has implications for the completeness of our dataset for Neolithic monuments in the White Peak, and leaves a very real possibility that others might also be reclassified in the light of modern excavation. With this in mind, it seemed important to capture the site as it was being excavated, prior to possible total destruction. It should be noted that the effects of quarrying here would be enormous, and would affect the whole character of the immediate landscape. If this landscape is quarried, this representation might be the most complete record of the monument in its landscape that is left.

6.3 Discussion

Like many techniques, PVR has both advantages and disadvantages, and these should be made explicit to avoid uncritical use. Many of the pros and cons of the techniques documented in the literature have also been encountered in this study, and so these are all considered together.

Some of the problems associated with the technique are procedural, relating to the procuring and processing of the source images. The issue of image alignment was a problem noted by Anderson, and was also encountered in some of the very early prototypes created in this study (Anderson 2003, Cummings 2000a). In order for the stitching software to work properly, it assumes that all the images are correctly aligned – this means that the images are level (perpendicular to the ground surface) all the way round the panorama, and are taken at fixed and known intervals, with sufficient overlap between each frame. Trying to achieve this with a standard camera tripod in the field is very difficult, but failure to do so will yield poor or no results (ibid: 23). Most of these potential problems can be avoided in two ways. Firstly, using a camera mount specifically designed for panoramic work is essential for any serious work. These facilitate easier levelling than a standard camera tripod, and can be set to rotate at fixed intervals between each shot. Secondly, a good quality, robust tripod with properly working spirit level is equally essential, and as much care should be taken in levelling the camera mount as one would take in any other surveying operation.

A second problem comes in ensuring even exposure between all the individual frames in a panorama. The effect of failing to do this is clearly demonstrated in the example of Green Low above, and has also been noted by Anderson (2002) and Cummings (2000a, 2000b). Problems can arise either outdoors, when one inevitably needs to shoot some frames into the sun, or indoors, such as at Pompeii, where lighting conditions are generally irregular. Apple recommend outdoor panoramas be shot at noon, when the sun is directly overhead, but this is not always practical, especially if one has an ambitious schedule of panoramas to procure (Anderson 2003). The problem can be exacerbated when using a digital camera set on "Automatic" mode, where the camera will attempt to reduce the exposure when facing into the sun, as it did at Green Low. The same problem can occur on sunny days with occasional cloud, as these can cause variations in lighting conditions that the photographer may not notice when concentrating on the actual shots (or rather not forgetting any frames, which does sometimes happen – Node 4 at Five Wells had to be shot on two separate occasions because of exactly this). The answer to this problem comes down to basic photographic technique. The experience accrued over the duration of this study suggests that the best option is to find some compromise between the brightest and darkest areas of the area to be photographed, and to "lock" the exposure to this. This was done in the panoramas shot at Tideslow and Five Wells, where despite many of the images being taken in the mid afternoon, evenness of exposure is generally good. Generally speaking, digital cameras are far more forgiving on bright sunny days rather than dull overcast ones. Although the exposure can sometimes be ramped up using image manipulation software such as Adobe PhotoShop, this is not always satisfactory, sometimes introducing "noise" into the image.

Another problem encountered in this study (as at Five Wells, and also Green Low) is the tendency for the images to become somewhat "flattened", with objects in the near distance seeming relatively far away compared to objects in the far distance. This again is a procedural matter. The problem occurs with modern compact digital cameras, which are often fitted with wide-angle zoom lenses. Exactly the same problem occurs when shooting video of landscape features, even on a broadcast quality camera. Fixed focal length lenses of a narrower angle suffer less from this, as can be seen in some of the panoramas taken at Gardom's Edge (Bevan et al 2002).

More general problems of image quality and resolution were noted in the examples of Tideslow and Five Wells above, where landscape features clearly visible in the field did not translate directly to the panorama. This is because of two pragmatic reasons. Firstly, for these panoramas to be efficiently viewed over the web without requiring too much bandwidth, their file sizes need to be kept to a reasonable size. Secondly, in order for the stitching software to be able to cope with the images in the first place, they may need to be resized from their original source format (3072 by 2304 in the case of Tideslow, Five Wells and Longstone Edge). The steps taken to enable both of these inevitably result in loss of data (by either resizing or compression techniques), which inevitably results in degradation of image quality. This must question any assertion that these images provide an "objectified view" of the landscape (c.f. Cummings 2000a), and the whole concept of "photo-realism" becomes somewhat elastic. The problem can be countered at least in part by providing access to uncompressed images of key landscape features, as in the examples of Tideslow and Five Wells.

Some of the other problems with this approach are more theoretical. The main problem noted by most authors is the limited nature of the interactivity, where views are constrained to the location of the nodes (Cummings 2000a, Edmonds and McElearney 1998, Goodrick1999, Jeffrey 2004). Although the nodes can be interlinked to create the impression of a greater degree of freedom of movement, the viewers experience is still dictated by the choice of nodes, which defines any sense of "narrative". As a consequence, there is a "much larger burden of interpretation on the originator of archaeological QTVR panoramas", as the viewer may unwittingly place great significance upon these, even if unintentional (Jeffrey 2004). This may not be such an issue for a simple ground-truthing exercise, but is more problematic if the panorama is intended to represent some kind of experiential journey through a landscape. This then becomes highly subjectified, with the narrative being dictated by the producer of the panorama, who may bring the same subjective biases into play as with any other form of representation. An example of this from this study can be seen at Five Wells, where the nodes' locations were chosen on the basis of observable viewshed phenomena. This is neither objective nor theory neutral, but instead is driven by the broader research agenda of the whole thesis.

The choice of nodes may also be dictated by range of criteria (ibid). For example, node locations may be chosen so as to obtain the best view of a feature, rather than to represent some archaeological point of interpretation. This again may depend on the perspective of the producer of the panorama - one from a media production rather than archaeological background might be influenced more by aesthetic than archaeological values.

The limitations on interactivity and navigation can be ameliorated by providing panoramic models with many interlinked nodes. Informal feedback from users suggests that this can however result in some level of disorientation. Larkman has suggested that "for someone who has not visited Roughting Linn, however, the beginnings of a mental map should have started to form after a few minutes navigation". This is not in anyway tested in this work, so may not be a realistic expectation. Neither is it necessarily desirable - the idea that the viewer is presented with an array of embodied first person landscape perspectives, from which they need to produce a "mental map" to understand, does seem a little anachronistic. Johnson found the absence of a map to contextualise this specific example problematic (2002).

A final theoretical criticism of this approach is that like all forms of visualisation, they assume a primacy of vision in perception (Cummings 2000a, Cummings et al 2002, Gillings and Goodrick 1996, Thomas 1993). This can be ameliorated to some extent by the inclusion of directional sound within the panorama, as facilitated by the use of some commercial packages e.g. SoundsaVR, Live Stage.

There are also several potential benefits to the use of PVR in archaeology. Often cited is the suggestion that the technique is relatively cheap, easy and quick to deploy. Whilst this may be true (compared to other techniques at least), it is an assertion that demands some qualification. In terms of cost, some initial investment is required. A camera is an obvious necessity, and if many panoramas are to be produced, a good quality digital one is the most cost effective long term, as film stock and processing costs will soon mount up. A good quality robust tripod is essential, as without this image alignment will become a major problem. If many panoramas are required, investing in a dedicated camera mount is also to be recommended. These two are very important – the technique is neither cheap nor quick if every one hour spent in the field requires four hours post-processing to correct mistakes. Finally, an appropriate choice of software is required. This study used Apples QuickTime Virtual Reality Authoring Studio, which currently retails at about £300, but there are many shareware and freeware solutions available, e.g. Helmut Dursch's "PanoTools". Speed and ease of production are largely dictated by the success of procuring properly aligned and exposed images in the first instance.

PVR models can be delivered in quite flexible ways, either via the Web or on CD-ROM. Whether delivered via Web or CD, PVR formats lend themselves well to being integrated with other forms of digital media and interactivity. This can be seen in the examples of Tideslow and Five Wells, where because the panoramas have been embedded in web pages, it was possible to provide the links to the high-resolution images using fairly rudimentary web authoring techniques. Further examples of how PVR models can be used with other forms of media are shown in the next Chapter. The basic format of PVR models can also be enhanced to create PanoraMaps, as in this study. The ability to link panoramas to maps enables the delivery of information rich virtual worlds, which can be of great benefit in educational applications (Dykes 2002).

In terms of Web delivery specifically, because the photo-realistic detail in the images has effectively been rendered "off-line" and compressed, they can be delivered quite effectively without requiring too much bandwidth. Because there are no solid models to be rendered in real-time, some of the performance issues found in more complex VRML models are avoided (c.f. Goodrick 1999). This does however come at a price, which is some sacrifice of image quality.

Implicit or explicit in the use of these models is the assumption that this form of representation, with its interactive and embodied viewpoint conveys a better "sense of place" than any other format short of an actual visit. This is arguably the single biggest attraction of the technology, and the one upon which all other cited benefits of its use are founded. It is also the hardest one to objectively evaluate, or as Cummings et al state "Although no one mode of representation can capture the multi-dimensional qualities of place, nor should it be regarded as testable, the methodology we adopt here does at least allow for a degree of clarity in the reproduction of experience that we feel was lacking from previous accounts" (Cummings et al, 2002: 59). Perhaps the only real test can be a purely subjective one.

As David Wheatley recently said about GIS based viewshed analysis, acknowledging that PVR techniques are not without problems is no reason to abandon them altogether (2004). As with any related techniques, archaeologists using these approaches need to make their shortcomings explicit. Despite the problems, it is argued here that PVR has a useful role to play, in archaeological research, presentation and education, and in particular, in addressing some of the issues encountered in GIS based visibility studies. As with viewshed, in purely pragmatic terms, these representations can serve as a useful adjunct to field work, especially when studying remote areas. Bradley has recently argued that monuments and landscape require repeated visits and prolonged exposure to enable their interpretation (2003). Using these representations could be one way of achieving this. Whilst these are still only visual representations, which may only ever facilitate a partial engagement with monuments or landscapes, it can at least be argued that "a sense of looking is reintroduced and motion returned to a two-dimensional page" (Cummings 2000b Section 6).

Chapter 7 - Exploring Arbor Low

7.1 Introduction

The aim of this chapter is to demonstrate how the use of VR and multimedia can be used to explore the architecture and landscape setting of a specific ceremonial monument in the Peak District – the Arbor Low henge, discussed in Chapters 3 and 4. This case study addresses each of the three main aims of the thesis as outlined in 1.4 in the following way.

Firstly, the case study uses both PVR and 3D solid modelled VR techniques to represent an intimate and close-grained engagement with the architecture of a specific monument. In terms of resolving human experience at different spatial scales, this approach is at the opposite end of the spectrum to the viewshed analysis presented in Chapter 4. Whilst the viewshed analysis itself is concerned with the individual human perception of landscapes and monuments, it concerns experiences of these that operate over more regional scales of resolution (Wheatley 2000). The VR representations presented in this case study specifically focus on how monumental architecture structures human experience largely within the confines of the monument itself.

Secondly, using the integrative techniques of multimedia, this case study explores potential areas of synergy between GIS analysis, PVR and 3D solid models, along with other forms of interactive digital media.

Thirdly, although the 3D model has been devised within the broader research agenda discussed in 5.5, it has been presented within the context of an educational resource, designed to enable students to heuristically explore the architecture and landscape setting of the Arbor Low henge. This demonstrates how, within the ethos of research and inquiry based learning, technologies that are ostensibly designed for research purposes can be used as learning resources within the current environment of UK Higher Education.

This is itself important, as research data in its raw form is not always suitable for teaching purposes (Kilbride et al 2002).

As the case study is presented as an example of how various digital media can be integrated to use as a resource for e-learning, the first part of this chapter will present an overview of Learning Technologies and e-learning, and how these sit within the broader pedagogical framework that is currently dominant in British Higher Education. Some specific attention is focussed upon how VR techniques can be used in such an educational context. The second half of the chapter presents a description of the resource itself, illustrating key features of the multimedia techniques deployed, and how these might be integrated into the curriculum. A discussion and critique is presented in the concluding section of the chapter.

7.2 The Broader Context: Pedagogy, e-learning and learning technology in British Higher Education

7.2.1 The Broader Context of Higher Education (HE)

To understand the importance and emphasis currently placed upon e-learning within Further and Higher Education, it is necessary to examine at the broader context of tertiary education itself. Quite apart from any technological revolution offered by new technologies, Further and Higher Education in the UK is undergoing a major shift in culture. There are increasing government initiatives in widening access to HE and increased emphasis on Lifelong Learning, along with the demands to produce generically "employable" graduates. In what is perceived as an increasingly globalised "education market", Universities are having to combat new competitors, whether they be other FE and HE institutions offering education delivered at a distance, or commercial concerns such as the new "corporate" universities. It is claimed that students will be from increasingly diverse cultural and social backgrounds, and that these students will require and expect similarly diverse and flexible provision of teaching (McElearney 2004, Ryan et al 2000). In addition to these demands, academics are increasingly operating within an "audit culture", wherein their own performance is subject to scrutiny both in terms of teaching quality and research output (Hamiliakis and Rainbird 2001). Lecturers in archaeology face challenges specific to the discipline, for example in delivering field based teaching (Holtorff 2001).

Many Universities have responded to these pressures by just doing 'more of the same'. More lectures are given to more students, tutorial group sizes have doubled, and the same practical classes have to be repeatedly run each week to 'process' the numbers. Inevitably there has followed a "loss of quality of learning experience for students", and a "need to find **pedagogically acceptable combinations of teaching methods** and cost structures to sustain increased student numbers" as reported by Dearing in his extensive review of tertiary education in 1997 (Dearing 1977, emphasis mine). Because of perceived "efficiency gains", many policy makers and University senior managers see e-learning mediated by the use of Learning Technology as a means of achieving this goal.

7.2.2 Basic Definitions and Pedagogical Approaches

7.2.2.1 E-Learning and Learning Technologies Defined

At this point it is useful to define "e-learning" as distinct from "Learning Technology", as the two often appear together, and are different although complementary. E-learning is a contraction of "technology enhanced learning". The "e" represents "enhancement", and so e-learning is often discussed in terms of the "e enhancement". This enhancement factor might be genuinely *pedagogical*, as in the example proposed here, whereby students gain access to a way of engaging with a monument simply not possible by other means. Often however this enhancement maybe purely *pragmatic*, for example as a means of providing distance-based students better communications facilities so as to try and replicate the kind of experience they would receive if studying on campus (Mayes and de Freitas 2004).

E-learning is a process experienced by students that is facilitated by the use of Learning Technology. E-learning is an inclusive phrase that implicitly puts the learner at the centre, rather than the technologies or the academic practitioners themselves – so it is not generally called "e-teaching". Learning Technologies in contrast are a group of related technologies that provide certain affordances that allow e-learning to take place. The use of Learning Technologies can be defined as *the systematic use of information and communications technologies that either facilitate or enhance the educational experience received by students.* Not surprisingly, this covers a very diverse spectrum, both in terms of the student experience and the way it is achieved.

7.2.2 E-learning Pedagogies

Learning technologies and e-learning are not theoretically neutral, but are based on underlying assumptions and principles about how learning takes place. These need to be understood before they can be used effectively.

Traditional "instructivist" teaching methods used in Universities for generations are being increasingly discredited, particularly under the current climate mentioned in 7.2.1. These are for two main reasons. Firstly, they do not adequately scale up to meet the demands of widening access and increased diversity. Secondly, recent pedagogical thinking views this approach as inherently flawed (Mayes and de Freitas 2004).

Based on principles of behavioural psychology, the traditional instructivist paradigm is criticised for being reliant on the notion that academic learning can be instilled in students by the simple transmission of facts and "knowledge". Learning is something that "happens" to students, and can be measured by their behaviour. Students have little interaction with the teacher or each other, and many activities where they exist at all, are so de-contextualised that they lead to knowledge that is 'inert' and effectively useless. Students come to think of concepts and facts as things to be memorised, and cease to explore them as tools to solve problems of their own needs (Grabinger and Dunlap, 2000). Opponents of instructivism would argue that their objections are not simply philosophical, but based on empirical observation (Mayes and de Freitas 2004).

During the last 20 years, this instructivist paradigm has become increasingly marginilised in favour of the "constructivist" approach. Based more on cognitive approaches to psychology, in constructivism, learning and understanding is *constructed by the learner*, rather than simply received from some external source. Concepts and facts now become tools of understanding that can be transferred from one context to another. Central to constructivism is the notion that learning should be active, through experimentation and observation, and that this activity should be directed towards the solving of realistic and relevant problems. Moreover, this active learning is not constrained to individuals, but takes place with an "activity system" – a group of people working towards a common goal via some sort of collaborative venture. In some earlier studies, instructivist and constructivist models were labelled as *reception* and *discovery* learning respectively (e.g. Castronova 2002, Gagne 1965, Novak 1980)

Following on from this, another important principle in constructivism is that learning is "situated", i.e. that it has a social component that in part at least determines the learning outcomes for those participating. In a constructivist environment, the role of the teacher becomes one of facilitator and guide, who will ideally encourage dialogue with and between students, use a wide variety of teaching resources, guide students through open ended questions, and accommodate various subjective and individualistic learning styles (ibid, Tam 2000, Alessi and Trollip 2001). Inquiry Based Learning (IBL) forms an important part of constructivist teaching strategies, and is regarded as a means of strengthening links between teaching and research (Jenkins et al 2003)

It is important to note that whilst e-learning and Learning Technology are not theory neutral, there are no paradigms inherent to e-learning per se, but that the affordances of e-learning and Learning Technology can be mapped onto existing pedagogical models. This has always been the case, and uses of

Learning Technology 20 years ago were just as instructivist as contemporary uses claim to be constructivist (Ravenscroft 2003).

Constructivism is a broad educational paradigm, and has been the subject of much educational research since the work of its founder, Lev Vygotsky, and some of its early proponents (e.g. Jean Piaget, John Dewey and Robert Gagne) in the 1960s and 70s. As the foundation of contemporary pedagogy, there has been a proliferation of models suggesting how e-learning can be deployed to achieve its aims, and these are well summarised by Mayes and de Freitas (2004). At many institutions such as the University of Sheffield, e-learning normally takes place within a paradigm of "blended" learning (Oliver and Trigwell 2005). This means the affordances of e-learning are realised within the broader curriculum of traditional "face to face" class based education (including seminars, field trips, lab classes etc). This is important because some of the more popular or high-profile strategies for e-learning have been specifically designed with distance based education in mind (e.g. Salmon 2000, 2002), and do not always map too well to the rather different requirements of conventional campus-based full-time students.

A Taxonomy of Learning Technologies.

Learning Technologies provide a number of often-cited affordances that make them powerful tools within a constructivist framework. These are that they can

- allow students to work at their own pace and place
- provide access to rich and diverse multimedia/teaching materials
- simulate real world problems and test scenarios
- facilitate communication and collaboration
- encourage active learning through discovery
- provide feedback via self assessment

Learning Technology resources are often delivered as one or a combination of the following types (Laurillard 2002, Alessi and Trollip 2001)

Tutorial Systems

Although very diverse in scope, tutorial systems are basically designed to 'teach something', originating in the idea that the computer can emulate the role of the teacher or some other component of the educational experience (Laurillard 2002). Whilst employing a range of the interactive multimedia techniques, they may often follow a fairly prescribed linear narrative, and the bulk of this narrative is often conveyed by text. In pedagogical terms, they tend to be instructivist in nature.

Simulations

Simulations are a computer based abstracted model of the world that allow the learner to interact with it and control parameters that affect its behaviour or state. Typically embedded within tutorial systems, simulations are often used to replicate practical (e.g. lab based) procedures, but can equally be used in broader scenarios e.g. 'how much of this site can be excavated within our budget?'. The BBC's "Hunt the Ancestor" is a good an excellent example of this, (http://www.bbc.co.uk/history/games/ancestors/index.shtml). The utility of such interactivity can sometimes be questioned: the student can just sit there and manipulate parameters at random until they get the "right" result, rather than actively constructing alternative models and testing their validity (Sim et al 2004).

Structured Resources and Information Retrieval

Structured Resources are designed to allow random access, sequential browsing, and most importantly, effective searching of electronic data. On line bibliographic databases and journals are one classic example of these - as well as gaining skills in efficient searching and data retrieval, increasingly students can gain access to the actual article. The multimedia capabilities of on-line systems allow images, video clips and other types of data to be accessed in the same way, allowing access to 'virtual teaching collections' of materials that would otherwise be impossible to maintain (Mowat 2002).

Computer Mediated Communications (CMC) and Collaborative Learning

The principles of constructivist education have prompted an increasing interest in computer mediated communication and collaborative learning (McConnell 2000). It is of increasing relevance to campus as well as distance based students. CMC systems are described as either **synchronous** (enabling real time discussion) or **asynchronous** (where there is an inherent delay between sending, receiving and replying to messages). Asynchronous communications are not dependant on everyone being on-line at the same time, and are logistically more flexible. In addition, in many asynchronous CMC systems e.g. bulletin boards, past messages remain visible and accessible for future reference, and in this sense the students can be actively and collaboratively involved in creating their own educational resource.

Computer Aided Assessment (CAA)

CAA allows students the opportunity to perform formative, self assessment procedures, enabling them to evaluate their own learning (Sim et al 2004). Typically this is mediated through multiple choice questions - the computer presents a question with possible answers, the student makes a choice, and the computer provides some feedback. Ideally the computer is non-judgemental, and can allow the student as many goes through the test as they want. CAA is often used in tutorial packages as a means of maintaining student motivation. The normal MCQ type format is necessarily fairly "closed", and is arguably too prescriptive for some disciplines (Clarke et al 2004).

Virtual Learning Environments (VLEs)

A VLE is a piece of software specifically designed to facilitate e-Learning in a holistic manner, theoretically providing all the "tools" required to house a complete on-line course. A VLE will normally have tools for structuring and presenting "content" (which can be in any digital format supported by the browser configuration), providing facilities for CMC and other collaborative exercises, as well as housing more administrative information such as course timetables, module descriptions etc (Cousin 2005). They are unique in that they combine content provision with pedagogical process. Not themselves theory neutral, they encourage the structuring of content into small and discrete chunks that make them ideal vehicles for delivering Reusable Learning Objects.

The now massively widespread use of VLEs in HE could be seen as evidence that e-learning is finally starting to become embedded within the culture of British Higher Education. This is certainly the case from a senior-managerial and resource allocation perspective, as they require significant institutional commitments in terms of hardware, software, and support staff (UCISA/JISC 2005). Their widespread adoption within schools and FE colleges in the last five years has driven student (i.e. customer) expectations to the point that no University can afford to be without one. This is Big Business, with the world's two largest companies supplying VLE software to FE and HE announcing a merger in August 2005 (Blackboard and WebCT). This has created an enterprise worth over two hundred million dollars, now accounting for over two-thirds of the world's market share of VLE software (A. Powell *pers comm*)

7.2.3 Current Developments in Learning Technology and e-learning

The burgeoning world of e-learning and learning technology now includes a growing body of research literature (Beetham 2005), new and emerging technologies, a bewildering array of definitions and acronyms, and a host of national bodies and initiatives with even more acronyms. The full diversity of interests represented in this eclectic discipline is beyond the scope of this study, but the following are illustrative of some of the current significant themes.

7.2.3.1 Research

Research into e-learning and Learning Technology has expanded enormously over the last 15 years, with Learning Technology emerging as a discipline within its own right (Conole 2004). Research is essential as the potential impact of e-learning and Learning Technology on institutions and individuals is massive, and the field is developing rapidly, both in technological and pedagogical terms. Historically, research interests have moved away from the more technical issues of content development, which dominated the early 1990s, towards more pedagogical issues, particularly those concerning communication and collaboration, integration within the curriculum, and organisational issues, such as the development of institutional strategies and frameworks for embedding the use of the technologies (Conole 2004, Squires et al 2000). The latter is important as Learning Technology is still considered a marginal interest in many quarters. With parallels in the history of GIS and Virtual Reality in Archaeology, Learning Technology has become a self-critically aware discipline, which seeks to situate itself within the broader context of contemporary pedagogical thought (Conole 2004).

7.2.3.2 Pragmatic Issues

Beyond the more theoretical considerations of pedagogy, there are practical and pragmatic issues regarding the development and use of e-learning materials. The following two examples are illustrative of these.

Reusable Learning Objects

One concern over the adoption of e-learning materials have been concerns over the cost of their development, which are arguably too high for any one institution to bare (Laurillard 2002). It has been argued that there are many areas within many subjects taught around the world that are effectively uniform, for example the sine function in trigonometry. If every lecturer in every institution that taught trigonometry created their own web resource to teach the sine function, the duplication of effort and cost would be frightening. Proponents of Reusable Learning Objects (RLO) would argue that there only needs to be one or a few well designed descriptions of the sine function, and using Internet technologies, these could be shared around the world (Downes 2001, Wiley 2001). The key here is that these are small bite-size pieces of learning resource that are shared, not entire courses, as the latter are too complex, unwieldy and often highly dependant on local factors.

Central to the success of this idea, is that each RLO should be adequately described using metadata (data about data) so as to enable efficient resource discovery, and that they should be "interoperable", which means their use should not be dependant on any specific delivery platform, medium or environment. A number of international standards exist to try and ensure this, for example the "Dublin Core" and IMS, for metadata and interoperability respectively. An RLO can be any digital object that can be shared (as is one of the video clips presented in the case study below), and it is envisaged that RLOs will be stored in content "repositories" such as JORUM, a project recently funded by JISC (see below), at http://www.jorum.ac.uk/.

Accessibility

In 2002, the SENDA legislation came into affect. Originating in EC legislation, it dictates that students with any physical or cognitive disabilities should not be disadvantaged with respect to accessing any educational experience, whether delivered via Learning Technology or not (Phipps et al 2002). With e-learning provision as being a major vehicle for widening access, the legislation is partly pragmatic, but has an ethical component as well. The ramifications for developers of e-learning materials are enormous, and many institutions are still only just coming to terms with its implications (see ALT-N online newsletter Issue 1 for some frank discussion about this amongst Learning Technology practitioners). An enormous subject in its own right, further information can be found at TechDIS (http://www.techdis.ac.uk), or at the Skills for Access website (http://www/skilsforaccess.org).

7.2.3.3 Affordances Offered by New Technologies

Many advances in technology are incremental, with existing technologies just doing the same but better or faster; but every so often a new set of technologies appear to have affordances that can facilitate change of practice at a paradigmatic level (Bonk 2004). One such area is that of mobile and ubiquitous computing, and the potentials they afford for mobile learning, or "m-learning" (Anderson 2005, Anderson and Blackwood 2004, de Freitas and Levene 2003, Wagner 2005). Ubiquitous computing implies not just mobile computing devices, such as laptops or Personal Digital Assistants (PDAs), but also the availability of network connectivity (usually wireless), which these devices can access. Mobile computing devices capable of connecting to the Internet now outstrip the number of desktop computers on many campuses, and the proliferation of wireless networks at many institutions means that a student can just as easily access their email and VLE delivered material from the Students Union bar as they can an IT centre. Learning can take place anywhere.

Of specific interest is the growth in functionality of PDAs over the last 10 years. No longer just glorified personal organisers, these devices are fully functional computers that can run the full range of "Office" software, as well as access the Internet. Importantly for Learning Technology developers, these devices can access an increasing range of multimedia, including interactive materials created with educational authoring software such as Macromedia Flash. Combined with GPS technology and digital cameras, these have exciting affordances for enhancing fieldwork, and indeed are already used for on-site excavation recording in a number of field units. Their potential has been acknowledged in educational applications such as medicine (Smordal and Gregory 2005, 2003), with their use being developed in other disciplines alongside archaeology (Dykes 2002, Kravcik et al 2004, Kukulska-Hulme and Traxler 2005). They will be considered again in 7.6.2 below.

7.2.3.4 National Bodies and Initiatives

The stakeholders involved in e-learning and Learning Technology include a number of national bodies, some of whose funding comes directly from central Government. Whilst being too many to list here, and subject to the occasional re-structuring, these are currently the major players:

Higher Education Funding Council for England – (HEFCE)

HEFCE are the central funding body for Universities in England, providing money to institutions for all aspects of their operations including capital expenditure and staffing costs. Much of this is directly related to student numbers, with a set amount payable for each "full time equivalent" (FTE) student. They also have an e-learning policy, but do not tend to fund individual development projects per se, but rather give money directly to institutions which can be ring fenced for teaching and learning activities.

Joint Information Systems Committee – JISC

Historically, JISC's main area of responsibility was in the development and maintenance of IT infrastructures, both within and between Universities e.g. JANET. In recent years they have adopted a central support role in the areas of e-learning and learning technology, and via their web site provide a wealth of information on everything from pedagogical theory to pragmatic advice on how to conduct a procurement exercise for a site-wide VLE installation. They fund a large number of projects and services, and are *the* main publicly funded stakeholder in e-learning in the UK HE sector.

The HE Academy - HEA

The HE Academy was formed in 2004 after a merger of the Learning and Teaching Support Network (LTSN), the Institute for Learning and Teaching (ILT), and the TQEF National Co-ordination Team (NCT). Its role is to support learning and teaching generally within HE, and although having specific interests in e-learning, its brief includes other areas such as accreditation for academic lecturers, and the maintenance of the 24 discipline specific "Subject Centres". These Subject Centres were formerly part of LTSN, and the Computing in Teaching Initiative (CTI) before that. The Subject Centre for Archaeology can be found at http://www.hca.heacademy.ac.uk/archaeology/.

The Association for Learning Technology - ALT

The ALT is the professional body for Learning Technologists and academics interested in e-Learning in the UK. It publishes a peer reviewed Journal (ALT-J), an on-line newsletter (ALT-N at http://newsletter.alt.ac.uk), runs two annual conferences, a large number of courses, and has over 200 Institutional members. It represents the interests of over 1,000 professional Learning Technologists working in HE, FE, and an increasing number of corporate bodies. The focus of the research published in the Journal and the conferences is more on pedagogy than technology, and as such is representative of research in the discipline as a whole. The association recently introduced an accreditation program to enable its members to gain professional recognition (CMALT), which will also lead to HEA accreditation.

The Maze of funding opportunities:

Some of these bodies give funding and others do not. Those that do, fund a number of services and initiatives at a national scale. Although this rapidly gets confusing, here are some examples:

TechDIS and CETIS are both examples of national services, funded by JISC. TechDIS has a brief to advise the academic community on matters pertaining to Accessibility and education, whilst CETIS work specifically on interoperability and metadata standards for RLOs. "Skills for Access" on the other hand, was a short-term development project funded by HEFCE to create an (excellent) on-line resource to advise Learning Technologists and developers on Accessibility issues specific to Learning Technology.

The Teaching Quality Enhancement Fund (TQEF) is central money from HEFCE, devolved to individual institutions to use as they see fit, but ring fenced for Learning and Teaching activities (so at The University Of Sheffield this money is used to fund a number of short-term development projects and cover some staffing costs within the Learning Development and Media Unit).

The Fund for Developing Teaching and Learning (FDTL) is administered by the HE Academy, and is allocated to projects on a subject-by-subject basis. Also administered by the HEA was the recent "Centres for Excellence in Teaching and Learning" (CETL) initiative, awarded to individual institutions. Again, consistent with broader themes, both the recent FDTL and CETL funding allocations have gone to projects focussing more on pedagogical process than subject specific content development.

7.3 Learning Technology, e-learning and Archaeology

As a discipline, both often highly visual and inherently collaborative in nature, Archaeology would seem ideally placed to exploit the affordances offered by multimedia, Learning Technologies and e-learning pedagogies, but how the use of these has penetrated HE is not clear (Kilbride and Reynier 2002). A needs analysis conducted by the LTSN in 2000 concluded that only 37% of academic staff in archaeology used learning technologies, but 58% wanted "access to more web based resources", which could be interpreted as indicating that there was a desire to use Learning Technology that has not yet been realised (Grant and Reynier 2001, Kilbride and Reynier 2002). The HE Academy have recently conducted a national survey regarding the use of Learning Technologies in archaeology education, but unfortunately for this study, the results are not yet available. That said, it is still possible to provide some picture of e-learning within archaeology, partly by looking at national initiatives historically, and also by reflecting upon activities within the Department of Archaeology here at Sheffield as a case study.

The earliest structured approach to using Learning Technology nationally came with the Teaching and Learning Technology Program (TLTP), in the early 1990s (Campbell 1995). This national initiative was funded by HEFCE, and its brief was to develop "courseware" (1990s speak for e-Learning materials) for core topics within a range of disciplines, including archaeology. The uptake of TLTP materials at The University Of Sheffield was inconsistent across the range of departments that could have used them. It was equally so within the Department of Archaeology, which was also a "provider" of one of the packages (a tutorial on animal bone identification). This was due to several issues, which to an extent reflect experiences across the country (Kilbride et al 2002). In some cases there were problems with technical implementation – for example many packages had not been written for delivery over a network, assuming their use on stand-alone machines instead.

Once these issues were resolved, staff interest in using the materials was inconsistent. This may have partly been due to a lack of dissemination about the materials' availability, and partly due to "not invented here syndrome". The latter can be a spectrum ranging from academic snobbery through to more legitimate concerns, often being that the material and approach were too generic (ibid). The generic and/or subjectively questionable nature of the content, along with little or no specific integration into the curriculum characterises large consortium projects, and the problem was not confined to Archaeology. Although the packages were generally well designed, the whole approach that most TLTP consortia took was to develop materials that were instructivist in nature, and these have been largely discredited since (Martlew 1995, Mayes and de Freitas 2004).

More recently, the Department of Archaeology has been the recipient of two internally funded TQEF projects. The first was to develop materials for use within a taught Masters program, and used both video and animation to demonstrate procedures for wet sieving soil for extraction of plant macrofossils, as well as producing a growing body of web based materials to teach pollen analysis. The second, currently under development, is rather more constructivist in nature. This project will re-structure first year teaching to provide a more inquiry based approach, and will use the University's VLE to facilitate communication and collaboration within tutorial groups.

In terms of national initiatives, the most recent round of the FDTL has allocated funds to three archaeological projects. One of these, Contact, is based in Sheffield, and will work to develop innovative technical and pedagogical approaches to the teaching of material culture. The University has also received funding in the recent CETL initiative to create "CILASS", the

Centre for Inquiry based Learning in Arts and Social Sciences. Archaeology are developing a project as part of this, which will entail the use of PDAs to survey burial plots in Sheffield's urban cemeteries.

Other recent studies looking at e-Learning and archaeology have embraced contemporary pedagogical issues, and have focussed more on providing flexible tools and resources rather than content per se. The recent PATOIS project (Kilbride et al 2002) provides tutorials on the effective use of the increasing array of digital data originated by and accessible to archaeologists for research purposes. The SCRAN project (Mowat 2002) provides a fully searchable database of multimedia resources, including still images, video clips, audio files and PVR representations. This serves effectively as a repository of Reusable Learning Objects, which students and lecturers are free to download and use. Wace and Condron (2002) have provided an excellent case study on how online materials can be used for tutorial teaching. Their study contains useful and pragmatic guidance on availability of resources, copyright, evaluation and possible teaching scenarios. Although many lessons have been learned from TLTP, disseminating these projects can still be problematic (Kilbride et al 2002, Mowat 2002).

7.4. Virtual Reality in Education

Virtual Reality has enormous potential for use in education, and its use has steadily grown throughout the 1990s. One of the most comprehensive reviews during that period summarised over 55 different projects in use, of which 7 had an archaeological component (Youngblut 1998). Only 1 dealt with archaeology at HE level however, and there was little in-depth discussion or evaluation of the provided. Unfortunately the number of available studies looking at the use of VR within HE archaeology courses is virtually zero.

In general terms, VR offers affordances that are very attractive to educators. In immersive VR systems, students no longer have to look at data on a screen, but instead are situated within the data itself. This is the concept of *presence* (Jackson and Fagan 2000). The less obvious the interface, the higher the degree of presence (note that this is not "the more realistic it is, the higher the presence"). Students can interact with elements in the representation directly, which could be stimulated by some form of behaviour or action built into the VR model (known as *autonomy* - ibid). The inherently visual nature of the VR medium enables abstract concepts to be displayed graphically – for example our trigonometric sine function discussed above (7.2.3.2). VR environments enable students to access places or events that are otherwise impossible because of distance, safety, cost, or the fact that the "reality" represented took place 5000 years ago. This is important in archaeology as we often talk about places that no longer exist, or are in a form no longer visible in any meaningful way (concrete posts at Woodhenge leap to mind here).

In VR representations, students can experience models directly, without having to understand and decode "symbols", or have them explained. Symbols in this case refer to domain specific forms of knowledge representation, such as musical notation, or algebra (ibid, Moore 1995). In the case of archaeological monuments, these symbols would be in the form of plan and section diagrams. By direct manipulation of objects in virtual world, students can alter and construct new realities around them. This self-constructed knowledge would be highly individualised and this may be more valuable than knowledge learned in other ways. Equally, in a multi-user environment, this knowledge could be constructed collaboratively. VR models can also be modified in the way a student sees fit, allowing them to explore their own subjective conceptions, and experience their own meanings, allowing a multivocality of expression. A summary of some of suggested contributions that VR can make to learning are listed below (Dalgarno et al 2002).

- Facilitate familiarisation of inaccessible environments
- Facilitate task mastery through practice of dangerous or expensive tasks
- Improve transfer by situating learning in a realistic context
- Improve motivation through immersion

- Reduce cognitive load through integration of multiple information representations
- Facilitate exploration of complex knowledge bases
- Facilitate understanding of complex ideas and systems
- Facilitate understanding of complex ideas through metaphorical representations

Although quite independent in their histories, there does seem to be quite close correspondence between the affordances offered by VR and the aims of constructivist education across a range of disciplines (Cronin 1997, Dalgarno et al 2002, Fallman et al 1999, Jackson and Fagan 2000, Moore 1995, Sanchez et al 2000). In archaeology specifically, Roussou has cited Papert's refinement to constructivism, constructionism, whereby knowledge creation is made even more potent by the process of physically creating or altering objects (Papert 1980 in Roussou 2004). Some authors have stated that the key to using VR in a constructivist sense is in its immersive nature, due to the reduction of cognitive load provided by the first person nature of the engagement with the world, and that this is less effective in desktop systems (Cronin 1997, Psotka 1995, Winn 1993). Desktop systems do none-the-less provide interactivity and a direct experience without recourse to decoding symbols. It might be that in specific training contexts that the immersion is important, rather than for more conceptual understanding.

Although VR has been used in a wide range of educational applications, the number that are relevant to archaeology as taught in HE are small, the majority being focused on school children (Clark et al 2003, Drettakis et al 2004, Gaitatzes et al 2002, Rousseau 2001, 2004, Sanders 1997, 1999, 2000, Sanders and Gray 1996, Sideris and Rousseau 2002) and more general heritage and "edutainment" audiences (Song et al 2004). Those most relevant to this study have been developed ostensibly for research papers, as discussed in Chapter 5, section 5.6 (Earl 1999, Goodrick and Harding 2000, Pollard and Gillings 1998). Somewhat ironically, it was the proposed use of VR in education that was the focus of Paul Reilly's original discussion (1991. 1992).

Evaluation is essential when looking at the use of any Learning Technology, especially one with cost implications as high as in VR applications. Fallman et al (1999) state that some research has been conducted looking at their effectiveness in "training" situations, such as vehicle simulation, military scenarios, and surgical procedures (e.g. Seymour et al 2002). Other evaluations look at the technology's effectiveness in teaching other aspects of spatial learning (Dalgarno et al 2002), or realism and performance of tasks (Drettakis et al 2004). Little work seems to have focussed on more conceptual understanding, and in reality, this is much harder to evaluate (Sanchez et al 2000). The specific evaluation of VR environments for heritage applications presents its own problems, and some of the techniques applied in more behavioural studies are not always relevant (Champion and Sekiguchi 2004). Equally, integrating the use of VR with conventional assessment strategies could also be problematic (Fallman et al 1999).

Summary

E-Learning has grown enormously over the last 15 years, partly in response to perceived challenges to Higher Education. During this time, there have been significant changes both in technology and pedagogy. At the time that the TLTP was conducted, Internet use was still very much in its infancy, whereas now its use for delivering e-Learning materials is almost taken for granted. Also during this time, pedagogical trends have started to move away from instructivist teaching methods, towards constructivist learning environments. Virtual Reality is a technology that can be used to facilitate constructivist learning experiences, although their potential does not yet seem to have been fully realised in archaeology. The rest of this chapter will focus on the Exploring Arbor Low case study, which aims to exploit some of this potential, in the context of a multimedia learning resource. Before that however, it is necessary to establish some archaeological context, both for henge monuments in general, and the Arbor Low henge itself.

7.5 The Arbor Low Henge

As introduced in Chapters 3 and 4, Arbor Low is one of two henge monuments in the Peak District, the other being the Bull Ring, which is similar in both size and architecture (Barnatt 1990, 1996b). Arbor Low is located almost exactly in the centre of the White Peak, placed on the northern facing side of a fairly prominent ridge, overlooking the southern entrance to Lathkill Dale and the Monyash basin.

7.5.1 The Context of Henge Monuments

Dating from the Later Neolithic, henge monuments are a peculiarly British phenomenon (Harding 2003, Pollard 1997). While examples are known from Ireland, there are few real counterparts in mainland Europe. Henges are defined by their architectural configuration, comprising a circular or sub-circular ditch with an external bank, normally interrupted by one, two or occasionally four entrances. These, and broadly contemporary unenclosed stone circles, represent something of a departure from the earlier tradition of Neolithic burial mounds and causewayed enclosures.

The most famous example is Stonehenge, although this does not clearly represent the classic (and more common) architectural form as seen at Arbor Low or Avebury. That the banks of henges are external to the ditches opposes any defensive interpretation, suggesting if anything they serve to keep people within rather than without. Their distribution ranges from the Orkneys to the south coast, and in some places appear in concentrations, as at Thornborough in East Yorkshire, and Knowlton in Wessex. Their sizes range from 10 to 480 metres in diameter, with Arbor Low measuring about 70 metres.

Some authors have suggested that henges may be seen as an extension of the earlier tradition of causewayed enclosures (Edmonds 1999a, Pollard 1997), although they also have parallels with earlier burial mounds in that all three monument types often used boundaries of one form or another to separate a particular space from the world beyond (Bradley 1998, Thomas 1999). As with causewayed enclosures in particular, the potential for substantial numbers of people to assemble within many henge monuments suggests they may have had a more regional focus than many earlier burial mounds and smaller stone circles, which also proliferate in Britain during the Later Neolithic and Bronze Age. One thing at least is certain; many people would have been involved in the construction of specific monuments, and it is likely that the very act of labouring in this way broke with day to day experience and brought a broader social world into focus (Edmonds 1999a).

Of greatest significance to most authors has been the ways that the architecture of henge monuments drew a line between the space within the monument and that outside, and how this spatial distinction was implicated in the reproduction of salient social differentiation. In gross architectural terms, this is most obvious in the form of the bank and internal ditch. These often (but not always) obscured proceedings within the monument from those standing outside, and constrained the views of those within, effectively creating a "world in itself" (Bradley 1998: 127). Many henge monuments also contained a number of architectural features within the earthworks to further accentuate this distinction. In some cases these were concentric circles of timber settings, as at Woodhenge, Durrington Walls and the earlier phases of Stonehenge. Some of these internal circles also had facades to direct movement and restrict views still further (Barrett 1994, Thomas 1999). At some monuments, this internal circular motif was played out in the medium of stone, which could suggest a continued interest in/celebration of the ancestors (Parker Pearson and Ramilisonina 1998), and/or a sense of durability of a new order (Edmonds 1999a). In some cases additional elements of a more temporary nature were established, as indicated by numerous smaller postholes at Coneybury Hill, Moncreiffe and North Mains. In some examples, some interior features predate the bank and ditch, as at Cairnpapple, Arminghall and Durrington Walls (Thomas 1999).

Many henges seem to direct attention towards the centre of the enclosed space, a zone sometimes elaborated and further defined by cove-like structures, a development seen at Avebury and Arbor Low. All of these features could serve to both restrict visibility from certain points, and to guide and structure movement within the enclosed space. The space inside the monument could have afforded further differentiation beyond the existing distinction between those within and those outside. Processional movement, as structured by the internal architecture, could have afforded selective and sequential moments of revelation and/or hidden-ness. One's own location within all of it meant something.

Burl has argued that henges and unenclosed stone circles represent similar ideals, but differ in terms of their geographical location (1976). Henges, he argued, occur where the underlying bedrock was amenable to the digging of substantial ditches, as in the chalk downlands of Wessex, whereas stone circles tended to be found in areas of more resilient geology. There are anomalies to this scheme, where henges also contain stone circles. Arbor low is doubly anomalous in this respect, being built into very resilient underlying limestone, and possessing a circle of stones within the earthworks. This is also the case at the Ring of Brodgar in Orkney, where the ditch is cut into sandstone bedrock (Barnatt 1990, Bradley 1998). Bradley (ibid) has suggested that the importance of this distinction is secondary as compared to considerations of how these monuments were actually used in prehistory. It has also been suggested that henge monuments are often distributed close to fertile land, and from this it has been concluded that they occupied locations that were "central" with regard to settlement patterns (c.f. Barnatt 1989). This again is difficult to uphold, as the density of surface artefactual material is often no higher around these monuments than in the surrounding landscape (ibid), and in the case of the Peak, current models instead suggest that settlement was more likely to be concentrated on shelves and other settings on the sides of more sheltered river valleys (Barnatt 1996a, Edmonds 1999a, Edmonds and Seaborne 2001, also Chapters 3 and 4 in this study).

Rather than being at the centre of putative prehistoric "territories", henges seem to have been sited to facilitate accessibility from the surrounding regions. Many are built near major rivers and confluences, or other natural gaps in the landscape. Others seem close to the courses of major roads today, which indicates something of their topographic setting (Bradley 1998, Edmonds 1999a). Indeed, Buckley (2000) has drawn attention to a common close association between henges and major Roman roads, arguing that this implies a significant concern with movement and accessibility from a broad catchment. Arbor Low is not inconsistent with this, being sited close to the southern entrance to Lathkill Dale, as well as an important routeway used as a Roman road and continuing to the present.

In several cases, both henges and stone circles seem to echo something of their surrounding landscape. For example, the arrangement and heights of stones in the circle at Castlerigg, near Kendal in Cumbria seem to mirror the ring of hills that surround it (Barrett 2006, Bradley 1998). At Durrington Walls, the immediate view is curtailed by its location in a dry valley, and the earthworks would reinforce this perception. Avebury, being located in a large basin, is also encircled by higher ground. It could be that these monuments, at least in part, act as some symbolic representation or homology of the surrounding landscape. The architecture of many (but again, not all) henges would obscured much of the surrounding landscape for those who stood within them – Silbury and Windmill Hill are obscured from within the bounds of the Avebury henge, but visible when stood on its massive banks. This is one respect in which henges and unenclosed stone circles differ, as the latter are generally "permeable" allowing views to the surrounding landscape from within, and equally importantly, views to proceedings within the circle for those who stood outside (Bradley 1998). Both are similar in that they deploy the symbol of the circle, an archetype that "referred to a more general perception of the world" (ibid:123, Richards 1996).

Some studies have shown how a number of monuments were aligned on seasonal astronomical phenomena. This is most famously demonstrated at Stonehenge, whose axis is aligned on the midsummer's sunrise. Other monuments appear aligned on the midwinter sunset, as at Long Meg in Cumbria (Bradley 1998), and at Durrington Walls (Parker Pearson per comm). With its north western entrance facing approximately 315 degrees, this also appears to be the case at Arbor Low, although this has not been verified by field observation in this study. The alignment of these monuments need not suppose that their builders "worshipped" astronomical features any more than the east-west orientation of a Christian church does, but instead might suggest a more general interest in confirming "that periodic assemblies and life cycles were in step with a more basic cosmological order" (Edmonds 1999a: 146).

It was not just the stars then. Architectural features may have just as easily been inspired by the surrounding landscape and by location of other monuments. For many henges, like the causewayed enclosures that preceded them, both their landscape settings and architectural configurations suggest a degree of regional integration on one scale, but also the maintenance of hierarchy and structure; "monuments that bound the land together could still be used to selective advantage" (ibid: 147).

7.5.2 Arbor Low

The name Arbor Low appears to derive from the Saxon "Eorthburg Hlaw", meaning "earthwork mound" (Barnatt 1990). The monument has attracted attention at least since the antiquarian days of Pegge and Pilkington (ibid), and of course Thomas Bateman (1848, 1861), as well as a host of modern authors (Cope 1998, Edmonds and Seaborne 2001). Some depictions of the site from these early scholars are included in the case study below.

Unfortunately the site has never been properly excavated using modern techniques, with the only recent published work being that of Gray, at the beginning of the last century (Barnatt 1990). Gray dug two trenches at either side of the north western entrance, and another six trenches in the ditch, estimating its original depth to between two to three metres. The henge has two entrances, although these do not directly oppose each other, and the north western entrance is somewhat larger than that facing to the south east, being nine and six metres wide respectively. A limestone stump appears laid across the south eastern entrance, although this could have been dragged there from the circular arrangement of recumbent stones within the bank and ditch. There is no other evidence to clearly demonstrate the existence of portal stones at either entrance (ibid).

A very striking feature of the monument is the large (21 metre diameter) round barrow that appears to be superimposed in the south eastern corner of the bank. This barrow was excavated by Bateman in 1845, wherein he found a stone cist, containing burnt human bone and associated artefacts (a bone pin, some iron pyrites, a sherd of pot and an unidentified flint. There were also two pot vessels possibly of Late Neolithic Peterborough ware type. The cist itself appeared to sit directly on an old ground surface, and along with the Late Neolithic pottery, this could suggest that the barrow actually predates the henge itself, but this is equivocal (ibid).

Perhaps the most mysterious feature of this monument is the circle of recumbent limestone slabs within the earthworks, and it is not clear whether these were ever upright. Gray excavated around one stone, but found no evidence for a stone hole within which it may have been set. This stone (stone 13 ibid: 34 figure 11) has a wide base and could have stood upright unaided. There are seven "stumps" of stones buried in situ around the ring, suggesting these were once upright and may have broken off when falling over. The likely direction of fall of the other stones has also been plotted by Barnatt (1990). It is also possible that the stones could have stood upright without foundation settings, instead being supported by smaller stones placed around their bases - stones that would be of an ideal size for robbing and reusing elsewhere. In the 18th Century both Pegge and Pilkington noted accounts from local people claiming to have seen the stones standing, although the reliability of these cannot be assumed. Taken together, this evidence suggests the stones were once upright (ibid), but this would require modern excavation to verify.

At the centre of the monument is a "cove" like feature, possibly originally comprised of up to six stones. Two of these are very substantial, and Barnatt has suggested that these would have obscured views into this cove feature from either entrance. Gray attempted to excavate part of this feature, but it had already been somewhat disturbed, possibly by Bateman (ibid).

300 metres to the south west of the monument is Gib Hill, discussed in Chapter 4. This was excavated by Thomas Bateman in 1848, and this barrow is comprised of a Neolithic long barrow, with a later Bronze Age round barrow superimposed on top. The land around Arbor Low has been extensively enclosed in historic times, and the familiar patchwork of grazing land divided by limestone walling creates a landscape that bares little resemblance to what it must have looked like in prehistory. In the monument's current state, it is not possible to experience the affordances offered by the stones and the impressive bank and ditch to structure space within the monument in the same way as it is at say Avebury, where in its reconstructed state, subtle configurations can be played out by visiting the monument today. It is argued below that by using virtual reality techniques, these architectural affordances can begin to be explored, even if in a fairly rudimentary way.

7.6 The "Exploring Arbor Low Case" Study

The rest of this chapter focuses on the Exploring Arbor Low package. This has been designed to provide a series of multimedia resources that can be used in a range of educational contexts, and fore-grounded within the broader constructivist paradigm outlined in section 7.2.2 above.

Pollard and Gillings saw the combination of GIS and VR technologies as providing a unique opportunity, "Combined within a single analytical-exploratory environment, these technologies provide us with very different yet fully complementary and highly synergistic means of engaging with and exploring the Avebury Complex" (1998: 166). Using multimedia technologies, this environment can be enhanced using text, still and interactive images, video clips etc to create an analytical-exploratory-*explanatory* environment, as suggested by Reilly (Reilly 1991). For explanatory here read at least "contextualising" – for the educational paradigm in which such a resource is to be used, analytical-exploratory approaches are the very means by which students will construct their knowledge, but the success of this would be partly dependant on the contextualisation of the various multimedia assets presented. One important feature about this environment is that the affordances offered by different media types enable the monument to be encountered at different geographical scales. These can be in its broader landscape setting, using video clips of aerial footage, and also the more intimate nature of the architecture of the monument itself, using VR techniques.

The use of text has been kept to a minimum throughout most of the package for three main reasons. Firstly, text is notoriously difficult to read from the screen, and multimedia design principles suggest it should be used to provide as little information as is necessary (Alessi and Trollip 2001). If students are required to engage with extensive pieces of text it is better to provide it in a format that can be easily printed and read e.g. the Adobe Portable Document Format (PDF). Secondly, text in multimedia packages is generally used to provide a narrative structure to the package. This package has been specifically designed to be free of narrative, so it can be used as a resource within a constructivist framework, rather than acting as an instructivist "tutorial". Finally, following from this, although collated and delivered on CD-ROM, any one screen or functional unit could be taken out of the package and delivered via the web as a Re-usable Learning Object. This would require the relatively trivial re-packaging as a Shockwave movie, but more importantly would require the appropriate metadata to be provided for subsequent storage and retrieval from a content repository such as JORUM. It is intended that this becomes a deliverable outcome of the study.

It is argued that the package could be used in a number of contexts, four of which are suggested below:

1. It could be used as part of a course on British Prehistory, where it would act as an adjunct to the more conventional use of slides in lectures, more traditional library based resources, and field trips.
2. It could be used as part of a research design project. Students could be allocated a hypothetical excavation budget. In order to evaluate the site, they get one field trip, where they have to make as much judgement in the field as possible to inform their strategy. The package could serve as a guide in the field, and as a powerful and subjective mnemonic for future study, so their studies could be based around embodied simulations as well as plans, maps and videos.
3. As an alternative to field based activities, the students could be briefed to create an information board to use at the site, a guide book, or indeed an entire heritage experience. As with (2) above, their timetabled visit to the site could be restricted to one visit, and the resource could then be used as their primary source of data.
4. Fourthly, and more recursively, the package can be used to teach students and archaeologists alike about the principles of using New Media in archaeology. As well as illustrating the general approach, there are plenty of shortcomings for them to improve upon as an exercise in critique.

In the first three examples, the resource is not envisaged to be used as a replacement to valuable field experience, but as an enhancement. There is an emerging body of practice from other disciplines where this is taking place, e.g. geography and geology. Kent et al (1997) suggest four key stages in fieldwork education, and Learning Technologies can map onto all four of these (Dykes et al 1999, 2002):

1. Preparation and briefing. This includes academic context, logistics, and introduction to the specific study area
2. Engagement. This entails selecting appropriate field methodologies, selecting appropriate sites for investigation, and actual data collection via sampling or some metrical analysis

3. Processing. This comprises aggregating data (in collaborative situations) and analysis.
4. Debriefing and feedback. Arguably the most important component, it is in this phase the students will contextualised their own experience within the appropriate theoretical background, and provide feedback for assessment.

Typically Learning Technologies can be used to support objectives (1) and (4) above, including the use of PVR and VRML based approaches (Shortis et al 2004, Warne et al 2004). With recent developments in the functionality of mobile devices, objectives (2) and (3) are increasingly realisable (Dykes 2002, Kravcik et al 2004, Sugden and Whalley 2004, Wentzel and van Boxel 2004).

7.6.1 Key Features and Walk Through of the Package

The package was compiled using Macromedia Director. This is a high-end industry standard multimedia authoring package, and is widely used in educational multimedia development. Director is popular in multimedia development for a number of reasons. Firstly it has the widest support for different multimedia formats than any other commercially available package, including still images, video (including MPEG II, the format used in DVD production), PVR models (using Apple's QuickTime VR format) and importantly for this study, interactive three-dimensional models, using Macromedia's proprietary "W3D" format. Secondly, it has a very powerful programming language (Lingo), which enables the development of very sophisticated forms of interactivity, as well as controlling the behaviours of various multimedia assets. Thirdly, materials produced in Director can be distributed as standalone CD-ROM based packages, or via the web using Macromedia's very widely used Shockwave format. Finally, it has a very widely installed "user base", which means that there are a great number of multimedia developers worldwide who have been using it for a long time, with several very active Internet based user forums. The downside to this is that being a "fully featured" development environment, it has a steep learning curve, and learning to program in Lingo is essential for all but the most trivial tasks. Although heavily discounted in price for use in educational establishments, it is also very expensive, costing circa £1,200 to buy commercially.

The main emphasis of the package is the interactive VR model of Arbor Low, along with a PVR representation of the monument complex, including Gib Hill. Most of the other media types and interactions are included to illustrate some of the affordances offered by these media, and to place the VR representations into a broader hypothetical context. These, along with the basic navigation of the package, will be considered first.

NB: Instructions for loading the package, along with system requirements and potential problems are documented in Appendix A, in Volume Two of this thesis.

7.6.1.1 Main Menu Screen

After starting the package, the user is taken to the main menu screen, which is effectively a "table of contents". The package has been broken down into nine main areas, and these are described in the sections that follow. Placing the mouse over any of the subject headings will cause them to become highlighted (by changing to black) and will also reveal a short description of the section at the bottom of the screen (shown on Figure 7.1). This technique, known as a "rollover", is widely used in multimedia design (Alessi and Trollip 2001). Rollovers are typically used, as in this case, to reveal supplementary guidance or instruction, without requiring the screen to be too cluttered at any one time. Combined with the change in shape of the mouse cursor, they also provide a visual cue that something will happen if the mouse is clicked at this point. Clicking on any one of the headings will take the user into the appropriate section of the package.

7.6.1.2 Introduction

The introduction screen simply provides a very short introduction to the package. Were this developed for a specific course or field trip, typically this section would inform the students how they should use it, as well as clearly signposting any specific learning outcomes that they would be expected to gain from using it. In every "page" from this point on, the user can either navigate back to the menu screen, by clicking on the "Menu" button, or they can step through the package page by page in a linear fashion, by clicking on the "Next" or "Previous" buttons (see Figure 7.2).

7.6.1.3 Background

The next four pages provide some background information to the Arbor Low monument complex. In more general terms this area could be used to introduce any study area, before getting into specifics. The first of these four pages depicts a second type of rollover – a rollover image. By placing the mouse over various parts of the images (either of the two henge entrances for example), a label is shown identifying particular key parts of the monument complex (Figure 7.3). Although a fairly simplistic example in this case, it shows how even apparently static graphics can be given some interactivity, and a sense of exploration. This technique can be very effective for providing important explanatory information, without overloading the screen with information at any one time, whilst encouraging the learner to be more active in engaging with the content and exploring the material.

The next page introduces the Gib Hill barrows, and provides access to Bateman's original diagrams from his excavations in 1848. The next two pages provide some background information as to the approximate chronology of the henge and stone circle itself, along with two somewhat lavish reconstruction images. The timber circle shown in the first of these is hypothetical. Topic specific learning outcomes from these four pages are primarily to understand that this is that the henge and circle are part of a complex of monuments with a prolonged history, and secondarily that these sites also have a long history of research, dating back to Antiquarian interests. Students with an interest in the portrayal of archaeology and the history of its illustration will no doubt enjoy the two reconstruction drawings for a host of reasons.

7.6.1.4 Image Gallery

The image gallery contains links to eight individual images, which can be accessed by clicking on the appropriate thumbnail (Figure 7.4). The "Back to Gallery" on the subsequent image pages button takes the user to the page with the thumbnails. All the images depicted are relatively rare, and are not those often used to depict the monument in more general works. A possible learning outcome and/or related exercise could be to get the students to discuss these images within the historical context of the discipline, with particular reference to the ideals of Antiquarianism.

7.6.1.5 Plans Explained

This section is slightly more instructivist in overall design principles than most of the package. The key learning outcome of this section is to understand one of the main "symbol" systems in archaeology – how to read the convention of the archaeological plan. Although one of the great benefits of using VR representations in educational contexts is that students can interact directly with data without it being mediated by the symbols, there are of course very valid reasons why the students should understand the system. Firstly, the vast majority of sites and monuments they study will be depicted in this way, and secondly, it is a very necessary vocational requirement for those wishing to pursue archaeological careers.

The first page in this section provides a very basic introduction to why plans need to be understood. The second page describes how the stones of the circle and cove are depicted, using a graphical rollover to illustrate how the plan conforms to what is actually on the ground (Figure 7.5). The third and fourth pages explain the convention of using hachures, with the fourth page again using rollovers to contrast how hachures can be used to depict banks c.f. ditches.

The fifth page in the section introduces the first example of a VR representation of the monument. In this case, the banks, ditches and stones have been modelled, and the actual plan has been "draped" over the earthworks (Figure 7.6). This representation enables the user to make an explicit link between the conventions of the plan and the form of the actual monument. It is fully navigable in three-dimensions, using the following controls:

Press the following keys:

"F" – to move forwards in the model
"B" – to move backwards in the model
Left, Right, Up and Down arrow keys – to move left, right, up and down respectively
Spacebar – resets the view of the model to the original

Holding down the shift key whilst clicking and dragging the mouse over the model will rotate the entire model relative to the current viewpoint. Dragging from side to side will rotate the model in the horizontal plane, whilst up and down will tilt the model in the vertical plane, allowing for example the model to be seen in plan view. This interface can take some time to get used to, and is also used in the three models later on

The last two pages in this section provide two interactive exercises against which the students can test their understanding of the Arbor Low plan. The first of these two is intended to be at least in part a small amount of fun. The idea is to click and drag the corners of the image to try and make it stretch over the actual photograph of the monument on the page background (Figure 7.7). Some assistance is available by placing the mouse over the subtly coloured "Hint" button at the bottom of the page. The last page of this section provides a "drag and drop" quiz, against which the student can test their knowledge of the specific architectural features of the monument. This type of interaction is widely used in e-learning (Alessi and Trollip 2001, Sim et al 2004), and works by clicking and dragging the labels on the right hand side of the image onto the appropriate feature, using the mouse, and releasing the mouse button at the desired point (Figure 7.8). If it is in the correct place, the label will "snap" into position and stay there, and if not, will jump back to its original location.

There are important objectives behind both of these interactive exercises. Meaningful interaction can break up the potential monotony in simply clicking through pages of text and images, and is important for maintaining motivation. In addition, by providing appropriate feedback, learners can find these activities very useful in revision contexts. Both of these exercises could be used as summative assessment tools if used within a Virtual Learning Environment, and their "scores" could be logged in its student tracking mechanism.

7.6.1.6 Landscape setting

As with the previous section, this too has a more instructivist approach than the rest of the sections in the package, and it is the only part of the resource that delivers actual "narrative content", in the form of text and pictures. This is consistent within a blended learning approach, in which learning technologies can be used to combine content delivery and broader pedagogical processes. Importantly in terms of learning outcomes, it introduces the students to the idea of thinking about ceremonial monuments in relation to their broader landscape context, and particularly other contemporary and earlier sites. Equally importantly for this study, it shows how the results of the analysis presented in Chapter 4 can be integrated within a learning environment, and how the results of the use of one form of technology can be presented via another.

This section could be expanded to include a whole case study focussing on the use of GIS based viewshed analysis within the context of relevant archaeological theory. The ability to show different viewsheds and at different scales (on the third and fourth pages) also demonstrates another important multimedia technique, which is that of "image swapping", so as to provide access to more data without overloading the screen with content at any given time (Figure 7.9). An alternative to this would be to open up the different images in separate windows, which would enable side-by-side comparison of the different viewsheds.

7.6.1.7 Video Gallery

This section includes six video clips, which can be accessed by clicking on the appropriate thumbnail image on the gallery page (Figure 7.10). Video uses the power of dynamic images to convey information, usually accompanied with a spoken voice to explain what is being seen, and uses the visual rhetoric of certain production techniques to imitate the cognitive process of the student (Laurillard 2002). It can be very effectively used to give the student a view of the world they otherwise would not get, often for logistical reasons, and by simple virtue of the power of visual narratives (ibid). Digital video is much easier to "control" than its analogue tape based counterpart, so in a lecture context it is much easier to immediately repeat the clip without the problems associated with trying to rewind a video cassette back to the correct point in a programme, in a semi-darkened lecture theatre (see Figure 7.11 for instructions).

In the "Close up of Arbor Low" clip, the monument can be seen from a range of angle and heights, providing a view that no student could ever get in a conventional field trip. By dragging the position marker (see Figure 7.11) backwards and forwards, the students could heuristically investigate the monument from this privileged "god-trick" like vantage point (Haraway 1988, 1991). The second clip shows the monument complex from a much wider perspective, and conveys the gently undulating character of the upland White Peak well. The clip also shows the spatial relationship between the henge monument and the Gib Hill barrows. By referring back to the GIS derived images from the previous section, the students can get to see what the landscape depicted in the DTM actually looks like. The third clip shows the Minninglow Great barrow in its landscape context, and also from close enough to make out the form of its mound. Again this clip also shows the subtlety of the topography in the White Peak, and demonstrates that when barrows are described as being in "prominent locations", this can be a relative term.

The fourth clip shows the broadly contemporary Nine Ladies Stone circle, and some of the surrounding landscape of Stanton Moor. This well-known stone circle provides an interesting contrast to the henge monument at Arbor Low, as it is open and "permeable" to the surrounding landscape, but also placed topographically situated to have a restricted viewshed, and be hidden from much of the surrounding moorland. The second half of the clip shows some of the other burial features on this upland gritstone outlier, including two ringcairns and numerous smaller barrows.

The fifth clip is the opening sequence from "Exploring Prehistoric Landscapes". This programme was made by the University of Sheffield's Learning Development and Media Unit in 1999, and was commissioned to provide an overview to the study of landscape archaeology. Making extensive use of aerial footage and evocatively styled shots, along with atmospheric music and long, slow mixes of images, the clip admirably demonstrates another strength of video – motivation. Since the film was made, it has been digitised and lodged with the JISC funded Educational Media On-line (EMOL) content repository at EDINA, hosted by the University of Edinburgh. The whole program is freely downloadable to any subscribing institution, and could be used in a PowerPoint presentation in lectures, or integrated into other forms of locally produced learning resources. Although the programme is quite laden with narrative, this clearly illustrates the principle behind Reusable Learning Objects.

The final clip is purely to illustrate another affordance of three-dimensional modelling technology, which is the production of pre-rendered animations. These can usually be created from within the same modelling environment as that used to create the interactive models, in this case 3D Studio Max. Although not interactive as such, these pre-rendered scenes can enable forms of visualisation not possible in simpler interactive models, including certain lighting effects such as casting shadows.

7.6.1.8 Panoramic Virtual Reality

This section demonstrates another three examples of Panoramic Virtual Reality, as extensively discussed in the previous chapter. The first page contains a panorama comprised of five interlinked nodes, and this can be navigated in the same way as the examples shown in the previous chapter (Figure 7.12). The first node is located in the larger north western entrance of the henge, looking by default towards the cove in the centre, and the later barrow on the south eastern bank. Panning the view away from the monument shows the landscape mainly to the north and west of the monument. The land to the east is largely obscured by the local topography and the bank of the henge.

The second node is located close to the cove feature, at the centre of the henge itself. Panning the view from this point clearly demonstrates how the banks of the henge obscure much of the view to the land outside the confines of the monument, and conveys something of the sense of enclosure one feels from standing within. If the stones were upright, this would theoretically be the most secluded part of the monument (Barnatt 1990).

The third node is located at the top of the later barrow, in the south eastern section of the bank. The view from this point is markedly different from that at either the cove or the north western entrance, with virtually all of the monument complex and the surrounding landscape now visible. Those who may have stood here would have a vantage over those conducting rituals within the partitioned space of the henge, and also those who were excluded, beyond the confines of the earthworks. Looking south, directly away from the monument, Minninglow is also visible, although as with some of the examples discussed in the previous section, it is not as clear in the panorama as in the field. The ability to see both Minninglow and Tideslow, as well as the proceedings in the immediate vicinity, may have conferred deep significance on this location.

The fourth node is located between Arbor Low itself, and the Gib Hill barrows. Arbor Low is now skylined from this view. Looking towards Gib Hill, its asymmetric shape shows its earlier and later phases. The fifth node is located on top of Gib Hill itself, and again Arbor Low is skylined from this point. Both of the latter nodes show much more of the land to the west than at Arbor Low itself. Many of the surrounding hills have smaller later barrows on top, as has been noted around Stonehenge (Parker Pearson and Ramilisonina 1998).

This page also provides an alternative way of navigating the links between the nodes of the panorama. Rather than clicking on the hotspots within the panorama, clicking on any of the features in the "Go To:" list jumps directly to the appropriate node, although arrives at a slightly different view than when navigating via the hotspots (see Figure 7.12). This is one example of the degree of control over PVR representations that is available via the Lingo programming language. This could have enormous educational benefit within many disciplines, as hotspots can be coded to trigger a wide range of events over and above jumping to the next node, such as launching a video clip, opening a web page, or revealing more information. In this example, the approach can be used to provide a more directed "virtual tour" of the monument, rather than a more freely navigable and less structured environment.

The next page shows the same five-node panorama, although this has now been linked to an aerial photograph of the site, using the PanoraMap approach as in the examples in Chapter 5 (Dykes 2002). Because of the potential disorientation experienced in some PVR representations of unfamiliar places, the nodes have been anchored to a view of the monument that the students will have already seen, in the Introduction page (Johnson 2002). As a means of pre-trip briefing and orientation, this may be more effective in introducing the monument complex as a whole, than the previous panorama alone, although this supposition would require evaluation.

The final page of this section contains another example of an embodied viewshed (c.f. Exon et al 2000). This is comprised of a single node panorama, located at the cove feature, linked to a GIS derived viewshed map for Arbor Low, and is shown on Figure 7.13. This was originally created for two reasons. The first was quite simply to demonstrate how the GIS viewshed of the monument actually appeared from an embodied first person perspective, as in the examples of Green Low and Tideslow in Chapter 5. The second was to investigate whether there was any discernable relationship between the architectural form of the monument, and its view of the surrounding landscape, depicted by the viewshed map. This second point bares further consideration. Bradley (1998) has suggested that in several cases stone circles and henges seem to be in locations whereby their architectural form in some way echoes that of the surrounding landscape. For example the location of Durrington Walls within a dry valley means that it was already quite enclosed by the local topography, and the form of its banks serves to emphasise this (Parker Pearson *pers comm*). Similarly, Avebury is almost completely enclosed by hills, as are some of the more permeable monuments such as Castlerigg, and Long Meg and her Daughters. It is as if these monuments serve as some kind of representational metaphor for the surrounding landscape (Bradley 1998).

The situation at Arbor Low is slightly different, but very interesting, having parallels with Bradley's observations, but also locally variant. By virtue of its exact setting, which is just to the northward side of a fairly prominent ridge, and on land of a slightly northern facing aspect, it does *not* have a panoramic viewshed. Rather than being surrounded by a horizon of higher land, its viewshed is quite markedly filtered to the north, with land to the south completely obscured. It was noted above and in Chapter 4 that its location is also just to the north of the quite striking viewshed boundary between Minninglow to the south, and Tideslow to the north, the latter of which is theoretically in view from Arbor Low. Significantly perhaps, it is *near* the boundary of these two viewsheds, but not actually *on* the boundary. This very localised topography is apparent when comparing the views from the cove out through either entrance, with virtually none of the surrounding landscape being visible through the southern entrance. Looking closely at the form of the banks from the cove, they appear to become slightly lower in the northern half of the henge than in the southern half. Looking again at the form of the banks compared with the viewshed map, it appears that where the banks start to decrease in height corresponds almost exactly with where land on the horizon comes into view. The effect of this is twofold – not only do the heights of the banks echo the viewshed from the monument, but they also seem to explicitly focus the view into this viewshed. Although locally different to the conditions at Avebury and Durrington Walls, the monument does indeed seem to act as some kind of representation of the surrounding landscape, as suggested by Bradley. Why the monument should emphasise this view towards the north is not clear.

It should be noted that whilst this particular panorama has been presented within the context of a teaching package, it was produced to address a genuine research question. More significantly, the combination of the panorama with the viewshed map offers a real synergy in terms of interpretation, as this observation is very unlikely to have been made without juxtaposing both forms of evidence, and this phenomenon has not been commented on hitherto this study.

7.6.1.9 - Three Dimensional model

The next four pages in the package demonstrate the use of non-immersive solid modelled VR to represent Arbor Low. To summarise the arguments above, this is motivated by two key reasons. Firstly, it has been established above that monuments like Arbor Low can only be fully understood when encountered from an embodied perspective, and that this perspective can be at least partly provided using VR. Secondly, providing the ability to heuristically interact with the monument via a VR model, and importantly *alter its state*, provides the students with the opportunity to create their own subjective experience and interpretation of the monument, and through this, become engaged in constructing their own knowledge.

The three VR models presented here were constructed using 3D Studio Max (3DS), a high end three-dimensional modelling and animation package. The photogrammetric method used in the Negotiating Avebury project (Pollard and Gillings 1998) was considered but not used for two reasons. Firstly, because of the recumbent nature of the stones at Arbor Low, it would not have been possible to take photographs from all angles of the stones, which is necessary for this approach to work. Secondly, because of budgetary restrictions, only one piece of software could be purchased for the study, and so 3DS was chosen because of its flexibility, as the author plans to do further reconstructions in the future. Some evaluative work was performed using Photomodeler Lite, a freely available version of the software used in the Negotiating Avebury project, but limitations in this version rendered it unsuitable for this study.

Although 3DS is a very fully featured package, and some would say positively user-hostile as a result, the model was actually relatively simple to create. The earthwork features were created by firstly creating a simple flat plane, onto which a plan of the monument was *texture mapped*. The plane was then *deformed* to create the banks and ditches. The *soft selection* feature of 3DS is ideal for this, as it allows the deformation to be performed with a *fall off*, which creates a relatively naturalistic smooth effect. The stones were also created quite simply. Their outlines were traced off the same plan, as simple line features, and these were then *lofted* to turn them into simple three-dimensional solids. This means that they are all uniform in thickness, which is not totally accurate, but was considered sufficient for this "proof of concept" model.

In order to add the interactivity, the models were exported from 3DS into Macromedia's proprietary "W3D" format. These were then imported into Director. The navigational functionality (as seen in 7.5.1.5 above) was provided by pre-defined functions that are packaged with Director, as is the ability to move the stones and place them upright. The ability to realise this functionality without having to resort to Lingo programming make Director a very attractive option for delivering VR models. Although Lingo includes over

200 commands and functions for manipulating VR models, this rapidly becomes very complicated. Director also has some rather idiosyncratic features in the implementation of its three-dimensional functionality, having for example a completely different concept of X, Y and Z axes than those found in most three-dimensional modelling packages.

The first of the VR models in this section depicts a putative timber circle in the place of the stones. The model can be navigated in the same way as that in 7.5.1.5 above. This depiction is entirely hypothetical, as there has been no excavation evidence to suggest that there was a timber phase at Arbor Low, although it is entirely possible that there could have been, by analogy with other henge monuments such as Durrington Walls and Stonehenge. Although hypothetical, this demonstrates the important point that VR techniques should not just be used to reconstruct the monument "as is", but that they allow us to model alternative interpretations and possibilities, as in the Negotiating Avebury project (Goodrick and Gillings 2000). Further permutations could be explored within this – at the moment the model contains one outer and one inner ring of timbers. More concentric rings could easily be added to the monument, and more timbers could be created within each circle, so as to reduce the visual permeability of each one, and increase the sense of partitioning of space within. Importantly, the timbers can be quite quickly and easily modelled using a simple cylindrical primitive, which in this case was then duplicated to create the rest. A very simple texture has been applied to make them look wooden, but without needing to try and achieve photo-realism.

The second model depicts the monument largely as it can be seen today – with the recumbent stone circle and inner cove feature replacing the timbers. Two additional pieces o functionality have been added in this second page. Firstly, as with the first PVR model, a "Go To:" feature has been added, and this functions in the same way as in the PVR model above, as shown in Figure 7.14. The most important enhancement to the functionality of the model is that in this page, the stones can be lifted upright. This can be achieved by placing the mouse over a stone, so that the mouse cursor changes from the default pointer to a fist icon, and then by clicking and dragging with the mouse, as shown in Figure 7.15.

By doing this, the student can effectively reconfigure the monument and create an upright stone circle, creating their own subjective experience and interpretation in the process. Once all the stones had been righted, the student could then use the navigational tools to explore the partitioning of space affected by the stones in their new configuration. Rather than just idly play with the model, the students' exploration of the space could be guided, by getting them to consider some of the points discussed by Barrett and Thomas for Avebury and Durrington Walls (Barrett 1994, Thomas 1993). These could include but not be confined to questions such as:

- How in general terms does the vertical setting of the stones structure the space at the monument?
- In what ways do they restrict view within, into, or out of the monument?
- How might they structure or restrict movement within the monument?
- How might this create a hierarchy or division of space and time which was manipulated through ritual practices
- Is there any noticeable difference in the sizes of the stones throughout the monument?
- Do larger stones flánk or the entrances to the monument as at the southern entrance at Avebury?
- Do the stones block the entrance?
- Does being within the cove obscure the view to the rest of the monument?
- Is it possible to see inside the cove from other parts of the monument, or from the entrances? (Barnatt 1990)

These could be explored and discussed alongside other ideas such as the significance of the materiality of stone (Parker Pearson and Ramilisonina 1998). Because the model could be delivered as a learning object in a VLE, the students could be made to write a short account of their observations and this could be posted to a bulletin board to facilitate collaborative discussion. The package could be modified to as to allow the students to save their reconstructions, and these could also be used collaboratively with their colleagues, as has been done with the Digital Landscape Space project here in Sheffield (Clayden et al 2005).

The third page is effectively a duplicate of the second page, but with the stones already upright. All other functionality is identical. This is useful for several reasons. Firstly, after having spent some time modifying the monument themselves, there could be other occasions when they just want to explore the reconstruction itself. This is a very important design feature when creating learning resources, as it enables greater flexibility in their use. Students may often want to access a specific part of a resource for revision purposes, rather than have to work through all the material provided every time. Typically such resources will enforce a linear narrative route the first time the student uses the package, but will allow random access there after. Secondly, the manipulation of the stones themselves is a little awkward, and may not be accessible to a learner with restricted motor skills. By accessing this third page directly, they can experience the reconstruction without having to do it themselves.

In the fourth page, the PVR and three-dimensional representations have been combined (Figure 7.16). Both can be navigated independently using the same keyboard and mouse actions as in the previous sections. A rudimentary attempt has also been made to link their navigation together. This time, clicking on the "Go To" headings will change the virtual observer's position in both representations, to approximately the same location in each. Viewpoints have been provided for the north western and south eastern entrances, and the cove (which is the viewpoint shown on Figure 7.16). There is a discrepancy in the case of the south eastern entrance, as there is no panoramic node for this point, so the view from the later barrow has been used instead. As with the examples above, the "Go To" could be used to provide a more structured and guided engagement with the monument.

Putting both representations together is useful for two main reasons. Firstly it provides a direct comparison between the two methodologies. Compared to the relative photo-realism of the PVR model, the manufactured deficiency *and* intensity of the three-dimensional model is clearly illustrated. Both representations are to some extent hyperreal. Secondly, placing the two together could help students forge the important link between what can actually be seen today, i.e. a monument that has been altered and situated in an enclosed and agriculturalised historic landscape, with what might have been seen 4,000 years ago. The formation of this link can be a real challenge both for students and those who teach them.

7.7 Discussion

7.7.1 - Virtual Reality for Research and Teaching

The aims of this case study have been two fold. The first has been to explore how the development of a 3D VR model of Arbor Low can be used as a research tool that enables an embodied exploration of the architectural features of this monument. The second has been to demonstrate how this can be used as an educational resource, situated within the ethos of research and inquiry based learning in teaching in British Higher Education. The VR model has been presented within the context of a multimedia learning resource, and in doing so, has aimed to demonstrate how different types of new media offer different but complementary affordances for achieving certain learning outcomes. Some of the examples themselves are arguably somewhat rudimentary and abstract, in that they are not tied in to any current specific course. This does however illustrate at least the principle behind the development and use of Reusable Learning Objects (RLOs). If deployed as RLOs, the accompanying metadata would provide would the necessary information for "resource discovery", leaving the academic lecturer to provide their own subject specific for its actual use. As an example, the PVR model showing the viewshed of Arbor Low (7.5.1.8 above) could be freely downloaded from a content repository as is, e.g. from JORUM. The lecturer could then place it within their institutional VLE, and contextualised it archaeologically using the arguments that other authors have stated about the landscape setting of henge monuments, e.g. Bradley (1998), Edmonds

(1999a), and Thomas (1999). This would provide a theoretical basis for the students' exploration of the model.

The resource has been designed using fairly conservative but none the less tried and tested principles (Laurillard 2002, Alessi and Trollip 2001). The navigation system for example is clear and simple, and allows either a linear narrative or random access (Laurillard 2000). The interactions such as the drag and drop exercises and image rollovers are widely used and representative of e-Learning resources across a broad range of disciplines. The use of interactive 3D models within archaeological education is less common, especially in direct combination with PVR methods.

The use of the PVR representations builds on some of the principles discussed in Chapter 5. They provide photo-realistic and embodied views of the monument as it appears to day. On one level they could be described as being purely presentational, and could certainly be used in that context. The utility of these techniques in supporting field-based studies has been documented from other disciplines however, particularly in the areas of pre-trip briefing and orientation to the study area (Dykes et al 1999), and in some distance learning contexts, they have been used as part of a substitute for actual fieldwork (Warne et al 2004).

The PVR example showing the viewshed data has demonstrated that combining these two technologies can go further than simply documenting and ground truthing a viewshed phenomenon, as at Five Wells in the previous chapter. In this case combining the two has revealed a hitherto unrecognised observation of how the banks both echo and emphasise the viewshed from the monument, and act as a metaphor for the surrounding landscape (Bradley 1998, Richards 1996). Whilst this does not itself explain the phenomenon, it certainly adds more depth to our description of it. It would be worthwhile extending this approach to other henge monuments.

Central to the motivation behind this case study was to provide a contextualised vehicle for the presentation of the 3D VR representations of

Arbor Low, in which a research visualisation tool could be used within a teaching and learning environment. Earlier on in this chapter (but may be not ultimately), a mandate was suggested for the use of VR for the embodied exploration of specific archaeological monuments. Central to this was the argument that in order to investigate the spatial configuration of monuments, VR models do not have to aspire to be photo-realistic, and that the degree of realism they portray should be dictated by their purpose (Gillings 2002, Brodlie et al 2002). With this in mind, the VR model presented here acknowledges its manufactured deficiency, and achieving photo-realism within the constraints of the study was never the objective. Instead the models celebrate their manufactured intensity, and creating a hyperreal experience is part of their purpose – actually going to Arbor Low and lifting up the stones will never be a real experience for any visitor.

It can be argued that in this context, issues of manufactured deficiency can be easily dispensed with, as the resource was not originally conceived of as a replacement to experiencing the monument in the field. It was not designed to act as a surrogate for an objective reality, but instead as a means of enhancing students' understanding of an extant site that can be readily visited. More photo-realistic surrogates of the monument are provided in the format of the video clips and the PVR representation, and these could be used more specifically in pre-field trip orientation and briefing. The VR model itself could then be used more in post field trip debriefing and reflection, where upon the experience of visiting the monument could be contextualised within relevant contemporary theory. These are stages 1 and 4 of Kent et al's model of field-based education (Kent et al 1997).

7.7.2 E-Learning in the Field

Although in principle, all four of the above stages could be enhanced by the use of e-Learning resources, publications prior to circa 2002 tend to imply at least some degree of remoteness between the use of such resources and the actual fieldwork itself (Dykes et al 1999). The recent increases in the functionality of mobile devices and ubiquitous computing however provide affordances that could radically change this approach. Over and above their obvious portability, there are already affordances offered by PDAs potentially very beneficial to field studies, such as:

- Ubiquitous Internet connectivity, providing web and email access, including access to a VLE
- The ability to beam and therefore collaboratively share data between devices in the field, rather than having to wait until after the trip
- Location awareness so as to obtain relevant information about what is near by, or to store location for data collection
- The ability to record sound and thus record individual observations and commentaries
- The inclusion of cameras for taking pictures or filming short video clips
- Logging data via peripheral devices, or directly into spreadsheets or databases
- Provision of rich multimedia content in the field created in authoring packages such as Macromedia Flash.

This emergent potential for the use of e-learning in the field is starting to become recognised in other disciplines (Dykes et al 2002, de Freitas and Levene 2003, Kravcik et al 2004), and it is anticipated that specific case studies will soon emerge in the literature over and above statements of potential and intent. Although PDAs may not be able to deliver the full functionality of the Exploring Arbor Low resource at present, this could be enabled in the field by using the more mature and stable platform of the tablet PC – a fully functional but highly portable form of laptop. The ability to use the resource in the field has important implications both theoretically and pedagogically.

By using the resource in the field on a tablet PC, the student would be able to proceed around the monument using it as a digital field guide, enjoying the monument's undiluted authenticity as they go about their "partial and erratic" encounter (Barrett 1984: 12). In doing so, the VR models can be experienced and manipulated within the context of the real monument, allowing alternative interpretations to be created *in situ*. The realism of the models will no longer be a question, because the student or visitor will already be experiencing the real. The models will be authentic to themselves, because that is all that the models can be (Gillings 2002). Rather than having to *evaluate* the models in terms of their photo-realism, these comparisons can be dispensed with, instead leaving the student free to proceed directly on with *engaging* with the models. On a theoretical basis, this further negates the need to pursue photo-realism and visual concordance. On a pedagogical level, it arguably counteracts some of the criticisms of non-immersive VR environments (Winn 1993), as the student will already be quite literally immersed in the reality being portrayed. The use of VR models in this type of context is also referred to as "augmented reality", where the VR representations are used to enhance a conventional "visit". The ARCHAEOGUIDE project is an example of how this approach has been evaluated in an archaeological context (Vlahakis et al 2003).

The PVR representation of the site would also complement the use of the 3D model in the field. The student could accompany their actual visit by navigating the PVR scene. By experiencing the PVR scene in the field, it would help cement their understanding of the place. When they go to look at the PVR scene later, they will not just see the images, but will also hopefully have the memory of their actual engagement with the monument to draw upon. This would be further strengthened by providing access to both representations on screen at the same time, as in the last page of the resource.

A very valuable potential enhancement to the resource would to provide it with the functionality to make annotations in the field, rather than simply use as a guide. This could be achieved using the PVR model, the 3D model or both. The students could locate themselves at the appropriate point in either representation, enter "annotation" mode, and record either a voice memo or enter some text. Director would be able to store their location within either model, along with the annotation. The resource could then be put into "playback" mode, and every time they enter a part of the model that has an annotation, they could be prompted to listen or read. The possibilities afforded by using mobile technologies in this way clearly have the potential to radically transform the educational experience received by students in the field, as well as having broader applicability in other public heritage environments.

7.7.3 The Use of W3D vs. VRML

The decision to use the proprietary W3D format for the VR models seems in opposition to most other studies, which have delivered their representations via the VRML standard (Earl 1999, Earl and Wheatley 2000, Gillings and Goodrick 1996, Goodrick and Harding 2000), so requires some explanation. In addition to some of the problems reported in using VRML in other studies (e.g. poor performance, non geo-referenced co-ordinate systems, and limitations on texture mapping), at the time this part of the study was taken, it appeared that VRML had reached a hiatus in its developmental trajectory. None of the above problems seemed to be reaching resolution, and the only authoring environment that was sufficiently fully featured had been withdrawn from the market. This coincided with Macromedia's announcement that the (then) new version of Director would handle 3D models, and that this new functionality would specifically be integrated with 3D Studio Max. Combined with some already established knowledge of the Director environment on behalf of the author, this seemed the best choice. Whilst not conforming to the ideals of standards, this is a good example of the kinds of pragmatic decisions that sometimes need to be made in multimedia development. All three models are available in VRML format for archival purposes, but without some of the interactivity.

7.7.4 The Hype and Reality of E-learning

The VR models presented here have been contextualised within broader developments in Higher Education, and particularly in the emergent fields of learning technologies and e-Learning. Although practitioners and government initiatives are enthusiastic about the contribution of e-Learning to the future of

Higher Education, there is also an emerging critical stance that questions its appropriateness and efficacy. These criticisms are variously political, pedagogical, and/or pragmatic.

In the opening of this Chapter, the emergence of e-learning and related pedagogies were foregrounded in the context of emerging external pressures that confront Higher Education in the UK. These were mainly the government's widening access agenda, and the perceived threat of a globalised education economy. In parallel, recent developments in pedagogical theory were described as being aligned to the emergence of e-learning, and taken together, it was stated that these have been perceived as a means of responding to the above pressures. For Clegg et al (2003), the idea that globalisation presents a deterministic and unchallengeable vision of the future is deeply flawed, and it takes no account of academics' ability to "draw on their own pedagogic repertoires, practical wisdom and relative control of the curriculum to shape the ways in which innovation is implemented" (ibid: 40).

Equally, the widening participation agenda is seen simply as a means of increasing Britain's human capital in the emergent "knowledge economy", rather than being based on any ethical considerations of social inclusivity. Flexible learning facilitated by technology is seen as a means of producing a better skilled workforce, rather than a more qualitatively enriched society. Both of these result in an adoption of e-Learning that is uncritical, technologically deterministic and driven by an increasingly managerialistic culture. Rather than broadening social inclusivity, this adoption of learning technology simply serves to reify existing divisions; with pre 1992 institutions using technology to bolster their international reputations and penetrate perceived new markets. Less traditionally well off institutions are deploying the technologies just to cope with the demands created by increased student numbers (ibid). It is not without some considerable irony that in the time since Clegg et al wrote their critique, the Government's own flagship contribution to the furthering of Britain's knowledge economy, the UK e-University, has collapsed in a somewhat spectacular fashion.

Managerialist agendas are also impacting upon how e-Learning is practised in the field. This is particularly acute in the field of evaluation and research. Evaluation is of enormous importance to e-Learning practitioners. It is through evaluation that the effectiveness of any learning strategy is determined, and crucially for e-Learning, it is the means by which a large proportion of much needed research is conducted (Conole and Oliver 2003). There is a real concern that the ascendancy of evidence-based practice comes at the expense of more qualitative studies, the latter of which are more appropriate to educational research. This is particularly problematic within a discipline comprised mainly of individuals on short-term contracts, who are not only required to complete some developmental activity, but to evaluate it as well. Because there is a temptation in evaluation studies to focus on what can easily be measured (e.g. student performance), this becomes the focus of the activity. Because such developmental activities produce research output that feeds back into policy decisions (not a bad thing in itself), such policy decisions can become biased. This can result in a body of practitioners who are disempowered to act creatively (ibid).

Although recent trends in e-Learning have aligned practice with the paradigm of constructivism, this has not always been the case, and there is a much longer tradition of instructivist uses of learning technology (Ravenscroft 2003). The constructivist approach itself is not without its criticisms. The paradigm works well if one knows how to learn and facilitate learning within its principles, but often may not take account of the past experiences and expectations of entry level learners (Tam 2000). In a world of (anecdotally) increasingly instrumental learners, the opportunity for increased autonomy and self directed knowledge creation may not be welcome or appropriate. Opponents of constructivism would also argue that the flexibility of its approach is also problematic, potentially leading to inefficient learning. This is made more acute by the fact that constructivists are allegedly less concerned with formalised assessment than instructivists. Taken together, all these ambiguities may result in educational strategies that are very difficult to evaluate, and therefore build upon (Dick 1992, Tam 2000).

Using technology within a constructivist environment presents other potential dichotomies – if learners are expected to spend more time sitting at a computer, this may come at the expense of opportunities to socially construct knowledge, itself a key tenet of some forms of constructivism. The affordances offered by computer mediated communication could however be argued to counter this concern. Other concerns might be whether the use of new technologies represents any valid paradigmatic pedagogical shift at all. - the delivery of lecture notes online could be described as nothing more than instructivism delivered via a different medium (Clegg et al 2003, Tam 2000). It is worth remembering that many people currently teaching in Higher Education have not themselves been brought up in a constructivist environment, and knowing how to navigate this world is as new to lecturers as it might be students.

More pragmatic issues surround the implementation of e-Learning. Not least of these is cost. At an institutional level, implementing an e-Learning strategy is a major commitment – based on recent experience at Sheffield, deployment of an enterprise level VLE can typically cost up to half a million pounds in hardware and software alone. Staff development and recurrent support costs would increase this massively. At the level of the individual, the implications are equally great. Real concerns exist over increases in workload for academic staff, as they have to come to terms with new ways of teaching, alongside the ongoing pressures of administration and research (Fox and McKeogh, 2003). Experiences for both staff and students can be frustrating, especially at first (e.g. Mason 2000). Finally, whilst some institution wide surveys have indicated that students find the addition of e –Learning resources to their curricula useful and enjoyable, it would not welcome it as a replacement of face-to-face contact (Haywood 2004).

There is no doubt that e-Learning has the capability transform the educational experiences received by students, especially when it provides novel means of engaging with genuine research led questions and materials. E-Learning is not however a panacea, and there is no "one size fits all" approach to either learning technologies or the paradigms within which they are situated.

Education may well be undergoing a revolution, but it may not yet be one without bloodshed.

Chapter 8 - Conclusion

8.1 Introduction

This final chapter of the thesis will summarise the main findings and outcomes from the work presented thus far, and will evaluate the outcomes of these against the original aims of the thesis. As with all studies of this nature, there are many potential developments to pursue, and limitations and/or problems that could be rectified by further studies and refinements, and so these are also discussed. The chapter will conclude with some more general discussion, considering the broader implications of the thesis, and the implications of this for future directions, over and above the immediate limitations of the research as it stands.

Before summarising and evaluating the key original findings in this work, it is worth restating the main research aims that the thesis has sought to address:

- Investigate and evaluate how related technologies of GIS and VR can be used to address relevant Landscape Archaeology questions at varying scales.

- To evaluate the extent to which these technologies can be integrated, or can be used synergistically rather than as stand alone examples.

- To demonstrate how these technologies can be used both in presentation and research, and how in the context of current HE, these can be used as tools for the construction of knowledge.

8.2 - Summary of Key Original Findings, Comparisons with Other Studies, and Future Research

8.2.1 - Chapter 4 – Neolithic Monuments from the White Peak – Key Findings

The analysis has enabled the provision of a detailed qualitative account of the viewshed phenomena for the Neolithic burial mounds and henge monuments of the White Peak. This has not been offered in previous studies (Joyce 1995). The analysis has demonstrated noticeable heterogeneity in both the sizes and characteristics of the viewsheds amongst these monuments. It has shown that many of the burial mounds have viewsheds overlooking uplands areas that would have been suitable for seasonal grazing during the Neolithic, and this has been discussed within the context of seasonal mobility and the need to negotiate tenure over these areas, especially where land is in view of multiple monuments (Barnatt 1996a, Edmonds and Seaborne 2001).

The results obtained from the analysis have been discussed both in order of putative chronology, and spatial patterning, as suggested by Barnatt (1996a). This has partly demonstrated how changes in the scale of concerns from the early to later Neolithic may also be reflected in these monuments viewsheds. Part of this changing pattern includes the emergence of the passage graves, with their generally large and inclusive viewsheds, and it culminates with the two henge monuments of Arbor Low and the Bull Ring. The locations of these two henges has been discussed and compared in reference to other monuments, and has revealed quite contrasting results.

The combination of viewsheds using Cumulative Viewshed Analysis (CVA) has also been explored. This basic method has been enhanced so as not only to demonstrate where parts of the landscape and monuments are in view from more than one monument, but also to clearly indicate from which *specific* monuments these areas are in view. This method has been described in the study as the "2 series CVA method". The CVA has revealed some interesting *possible* relationships between monuments. Some of these relationships exist over quite restricted localised areas. In other cases these relationships have been demonstrated over significant distance, as in the cases of Minninglow and Tideslow. These would be very difficult to resolve via other non-GIS based techniques, especially with regards to phenomena such as the boundary effect around Arbor Low. The CVA has also demonstrated the existence of some interesting "palimpsests" of intervisibility around certain monuments, as at Five Wells. This latter monument is interesting because although not implicated in Barnatt's schema of Great Barrows for the Later Neolithic, it would appear to behave as one in viewshed terms. At the very least, this monument appears to form a juncture between the monuments in the northern part of the region, and those in the central and southern parts. This again would be very difficult to demonstrate via other means.

In viewshed terms, the monuments of the north-western zone appear to become quite isolated from the rest of the region by the Later Neolithic, with only Five Wells providing any sense of integration between these monuments and the rest of the region. Apart from this anomaly, and that of Five Wells, the results of the analysis are generally consistent with existing models for the region proposed by Barnatt (1996a), Hind (2001) and Edmonds and Seaborne (2001).

8.2.2 – Comparisons with other studies

This study has not performed any of the quantitative analyses that have been deployed in many viewshed based studies over the last 10 years (Joyce 1995, Wheatley 1995, Llobera 1996, 2001, 2003,). This has been for two reasons. Firstly, the Kolmogorov-Smirnov test (Wheatley 1995) has already been used to assess the statistical significance of intervisibility for the Neolithic barrows in the Peak District by Joyce (1995). Although this can be a useful procedure, it may also serve to govern the nature and scope of the interpretation of the available evidence. In cases where statistical significance cannot be demonstrated, authors may be tempted away from providing any further interpretation. Secondly, without any theoretical requirement to demonstrate that these monuments are sited to be intervisible, seeking statistical proof seems to be a little redundant.

Instead this study has chosen to place emphasis on providing a "thick" qualitative description of the results, and has sought to embed this within relevant archaeological interpretation of the region as a whole (Barnatt 1996a, 1996b, Edmonds and Seaborne 2001). Again, very few published studies have chosen to disseminate results in this way, with a notable exception being the work of Exon et al, around the Stonehenge landscape. (Exon et al 2000).

The 2 series CVA method does not yet seem to have found its way into the archaeological literature, so it is not possible to compare the results of this method with any others at this stage. Some of the more recent publications using GIS based viewshed analysis have demonstrated other enhancements to the basic methodology, such as the Higuchi Viewshed technique (Wheatley and Gillings 2000), or the assessment of "topographic prominence" (Llobera 2001). These enhancements (see 3.5.1, 3.5.3) were beyond the initial remit of this study, whose emphasis is placed more on the potential integration of techniques, rather than an in depth exposition of any one (Wheatley et al 2002).

8.2.3 – Limitations and Future Research

The GIS analysis presented in this study could be extended by future research both in terms of analytical methodology and archaeological scope. In addition, there are unanswered questions to pursue, which may not be possible to resolve immediately.

Since the analysis presented in this study was performed, new terrain data has become available, at a higher resolution of 10 metre grid squares compared to that of 50 metres used in this study. A first priority for any further research would be to recalculate the viewsheds using this new data set, with an observer height set at 1.57 metres.

Having done this, the viewshed analysis could be enhanced using some of the recent developments in methodologies discussed above and in 3.5, so as to provide a more nuanced study of visibility. Moving away from viewsheds from fixed locations, modelling mobility from areas of suggested settlement up into the upland zones may add a sense of dynamism into an otherwise static series of viewpoints. Route ways can be modelled by using Cost Surface Analysis, and the experience of travelling along these can be animated. This technique however is as equally awash with unresolved technical and theoretical issues as viewshed analysis (Llobera 2000, Van Leusen 2002). Not least of these is that a description of landscape experience is created out of a mathemetised relationship between some variable of topography, normally slope, against a relative but nonetheless linear scale of time. Weighting in these models is rarely apportioned culturally - here there is no social time, no sharing in mutually interlocking taskscapes (Edmonds 1999a, 2006).

In terms of archaeological scope, the study could be extended to include other forms of existing archaeological evidence. In the first instance this would include the ever growing body of lithics data, including that presented by Hind (2001), as well as the ongoing collection of material by the Arteamus group. This is imminent as the author is now a member of this group. The study has also only so far considered burials in barrows, and this should be extended to incorporate burial evidence from caves and rock shelters in the region (Barnatt and Edmonds 2002, Chamberlain and Williams 1999, Hind 2001).

The study should also be extended chronologically to include the stone circles and rock art of the later Neolithic and Early Bronze Age (Barnatt 1990, Barnatt and Reeder 1982, Barnatt and Robinson 2003). Moving onto the Eastern Moors, more close grained analysis of visibility and hydrology should be performed around the field systems and associated settlement evidence (Barnatt 1999, 2000), specifically for example around Gardom's Edge (Barnatt et al 2002).

Despite some attempts, the issue of vegetation still remains unresolved (Tschan et al 2000). The general availability of environmental evidence for the White Peak leaves a somewhat sketchy image of vegetational conditions in the Neolithic, over and above the indication that small-scale clearance was taking place. An obvious remedy to this would be the traditional call for more environmental evidence to be gathered for this region. This is unfortunately problematic, as conditions in the White Peak are not favourable for pollen preservation, effectively ruling out this major form of analysis. The effects of vegetation could be more qualitatively modelled using landscape visualisation software such as Vista Pro. Again this is not without its problems. Firstly, Vista Pro interprets terrain data using fractal algorithms to increase the realism of rocky outcrops etc, so there is an unknown uncertainty introduced into the model. Secondly the density of vegetation that can be created is also a function of the DTM resolution, and it will only draw a maximum of one tree per grid square. With a 50 metre resolution terrain model this would be inadequate for reproducing dense woodland or regenerating scrub. Finally, such visualisation methods would *only* reveal a subjective image, and would not facilitate the analysis of viewsheds from multiple monuments.

The significance of vegetation around Neolithic burial monuments in Wales has recently been discussed by Cummings and Whittle (2003), with specific reference to how the presence of woodland would affect views from these monuments to significant natural features in the landscape. Environmental evidence, where available, has indicated that there was significant variation in vegetation around these monuments, with some being located in relatively open and cleared landscapes, whereas others appear to be sited within more wooded settings. In the early part of the Neolithic, much of Britain was predominantly wooded, although clearance was taking place from the Mesolithic onwards (Simmons 1993). Although environmental evidence from the Peak District is quite impoverished, the region does seem to echo this general picture (Taylor et al 1994, Wiltshire and Edwards 1993).

Woodland environments would have been of great significance to people in the Neolithic, and would have been an important part of the seasonal round

(Edmonds 1999a, 1999b). Over and above a source of raw materials and food, Evans et al (1999) have discussed how woodland areas could have had great symbolic significance, possibly serving as metaphors for regeneration, ancestry and generational time. This may also be reflected in the use of wood in Neolithic mortuary structures, such as the enormous "megadendric" (ibid: 251) timbers found at Haddenham (Hodder and Shand 1988) and Fussell's Lodge (Ashbee 1966). Some tombs may have been deliberately located in woodland areas, and "trees may have been an integral part of the experience and use of early Neolithic monuments in their wider setting" (Cummings and Whittle 2003: 264). Such wooded locations may only have obscured views to and from monuments at certain times of year, with seasonal variation in the tree canopy creating different visual effects throughout the year.

Vegetational conditions would in any case have changed throughout time, with increased clearance taking place throughout the Neolithic (Taylor et al 1994, Wiltshire and Edwards 1993). Exon has noted how this could have a significant effect on how viewsheds would change over time (Exon et al 2000). Monuments may have been sited in locations where topographic settings afford long-range viewsheds, but vegetational conditions in the Early Neolithic may have prevented these from being realised. It is possible that visibility over such scale was not important when these monuments were first built, and that some of the long-range viewshed phenomena exhibited by monuments such as Tideslow and Minninglow were purely accidental products of human action (Wheatley and Gillings 2002). The long-range nature of some of these viewsheds may have only become apparent or significant as a result of increasing clearance throughout the Neolithic (Exon et al 2000, Taylor et al 1994, Wiltshire and Edwards 1993). It may be purely coincidental that this occurred in parallel with changes in scale of concerns from the local to the more regional, from the Early to Late Neolithic. Maybe regional scale viewsheds became significant when regional scale social relations and practice also started to form. This could in part explain why certain monuments became embellished in the form of Great Barrows (Barnatt 1996a). As visibility unfurled across the landscape during the Neolithic, so the unintentional long-distance nature of the viewsheds from some of these monuments became apparent. This may have influenced their selection as regional foci, as suggested by Barnatt (ibid).

Concerns over the use of ArcView's default height offset of 1 metre for creating the viewsheds presented in Chapters 4, 6 and 7 raises questions over what an appropriate choice of observer height should be for such studies. It was noted that more recent studies use an observer height typically around 1.6 – 1.8m (e.g. 1.63m chosen by Trick 2004, 1.75m by Woodman, 2000), which in the case of this study leaves a deficit of 0.7 – 0.8m. Sensitivity tests between 1 and 1.57m revealed some discrepancies in the resultant analysis, with the latter value unsurprisingly yielding larger viewshed areas, specifically over shorter distances. It should be noted however that given the topographic settings of many tombs in this study, one would only need to walk a very short linear distance towards or away from the monument to experience this height difference. Certainly any sort of processional movement around the monument would entail successive changes in viewer height of this magnitude. Equally, someone stood some distance back from a tomb partaking in a ritual gathering would experience a different viewshed from someone stood in the immediate vicinity, of the monument, such as a shaman in a performative zone (Barrett 1994). A choice of observer height of over 1.7m may also be providing a rather gendered viewshed, as this value corresponds more closely to the average height of a Neolithic male than a female (Roberts and Cox 2003). Perhaps we need to ask whose viewshed are we actually looking at? One answer might be to create a range of viewsheds at different observer heights, and combine these to create a *probable viewshed* for the monument (Wheatley and Gillings 2000).

Over and above all these considerations, there still seem to be questions over what the results of viewshed analysis actually *mean*. Earlier authors were happy to directly equate viewshed with a territorial function (Lock and Harris 1995), and explain monument location on that basis, but recent authors are more cautious, considering a wider range of criteria (Roughley 2001). Ethnographic analogy may enable a suggestion that the creation of mortuary monuments in the Neolithic fixed an ancestral presence in the landscape (Barrett 1994, Bradley 1984, 1993, Edmonds 1999a, Tilley 1994). Moving from this to suggesting that the viewshed from a given monument equates to some statement of tenure is rather more problematic, although arguably possible by invoking ideas from Foucault about the relationship between vision and control (Rajala 2004).

None of these problems need to prevent viewshed analysis from being worthwhile. It still indicates what can be seen from a given monument. Even if a monument was not sited with reference to exploiting a visibility affordance at all, the viewshed still gives another handle on the experience of one who was there, another nuanced insight as to what it was like to dwell in that world. Repeated visits to a locale in which a certain viewshed phenomena existed would eventually become entrenched in a person's experience of dwelling in the world, become part of their *habitus* (Barrett 1994). It does not have to enable the formulation of a model or system to be valid as knowledge – creating the images provides more information, and this is valid if reconstructing the experience of the individual is important at all. So whilst there may indeed be more to seeing than meets the eyeball, viewshed images are still worth a look. Taking all these issues together, perhaps we need to ask a question that is broader again – what are we actually *looking for* in viewshed analysis?

8.2.4 - Chapter 6 – Panoramic Virtual Reality (PVR) Key Findings

In conjunction with Chapter 5, this chapter has provided a necessary critique of existing work, and demonstrated a valid theoretical context within which this technique can be used as a research tool, rather than just as a presentational medium. On the basis of this, it has demonstrated the general affordances offered by the technology in reference to specific archaeological contexts (presentation of monuments, digital conservation of sites and landscapes under threat of destruction). The basic functionality of the technology has been enhanced using the PanoraMap approach, in which the panoramas have been linked to static images, with a directional pointer in the static image dynamically indicating what is in view.

Using the PanoraMap technique, it has been demonstrated how PVR representations can be specifically integrated with the results of viewshed analysis to provide a more embodied experience from the observers perspective. This is not possible from conventional viewshed maps alone, and has been termed the *embodied viewshed* approach in this study (c.f. Exon et al 2000). In the case of the landscape around Five Wells, it has been able to document the ground-truthing of a particular viewshed phenomenon, and provide a spatial narrative of the experience of this phenomenon that could not be achieved by other means (certainly not with static pictures, print or video), c.f. Tilley (1994).

8.2.5 - Comparisons with other studies

The number of publications featuring the use of PVR in research to date has been few, with most examples focussing on presentation in its broadest sense. Those that have used the technique in research generally present the panoramas "as is", without describing them in too much detail (e.g. Trick 2004, Cummings 2000b), or have described their production from a more methodological perspective (Milbank 2003, Jeffrey 2001). Although Trick created his panoramas to try and provide a more embodied presentation of his viewshed data in Romania, he did so without using the embodied viewshed approach, and so the panoramas and viewsheds remain isolated from each other (2004). The relevance of using PVR representations in landscape studies has been most clearly articulated by Vicki Cummings, and her theoretical basis for using the method has formed the foundation for that presented in this study (2000a).

The only other examples where PVR representations have been linked to viewshed maps to create embodied viewsheds appear to be those of Exon et al (2000). Some studies have sought to use a series of interlinked PVR nodes to provide a sense of spatial narrative (Larkman 2000), although again these have been without the benefit of the PanoraMap approach (Dykes et al 1999, Dykes 2002).

8.2.6 - Limitations and Future Research

This work could also be extended methodologically and archaeologically. There are also further theoretical issues to consider.

The methodological limitations regarding the resolution of images displayed in the panoramas could be quite easily be resolved by producing the panoramas on a more powerful computer, but unfortunately this was not possible at the time. Later versions of the QuickTime platform used in this study also enable the production of panoramas that offer a full 360 degrees of vertical navigation as well as horizontal. It should be noted however that taking full advantage of this more recent development also requires specialist wide-angle camera lenses, again incurring additional cost.

Archaeologically, the use of the PanoraMap technique should be extended to include more monuments. More close grained viewshed phenomena such as that around Five Wells should be documented using this technique. In terms of general presentation, more supplementary information could be included with the panoramas. The functionality of these could be further enhanced using the QuickTime and Director development environments.

On a more theoretical level, the use of PVR representations to convey a sense of *place* requires further consideration. It could be said that there is no sense of place without memory, and that peoples' sense of a place is constructed as a result of actually being there (Feld 2005). Following this argument, there is perhaps no reason why a PVR representation of a monument or landscape should convey a sense of place to someone who has never visited the location being displayed. Given the history of panoramic paintings, as a means of displaying exotic travel locations in the previous century (Krasniewicz 2000), perhaps the notion that a sense of place can be conveyed by a PVR is just a historically constituted one, just as is an uncritical conception of landscape (see 1.2.1).

To counter this, it could be argued that these representations are more closely bound to human experiences of the landscape than just a historical construct. When people engage with landscapes, they actively look around (Gibson 1979, Ingold 1993). Engaging with a PVR also entails actively looking around, as the panorama is inert until interacted with. Maybe this is an authentic representation of embodied human experience after all. As representations, the person to whom all these have most meaning is the author, as the one who went into the field, made observations, and took the actual pictures. Even if they only succeed as powerful enhancements to field notes, their use is still valid, (Bradley 2003, Cummings 2000a), and recent critiques of phenomenological studies have emphasised the importance of providing more objective observations (Fleming 1999, 2005).

8.2.7 – Chapter 7 - Exploring Arbor Low – Key Findings

The chapter has aimed to provide an up-to-date review of current developments in e-Learning and Learning Technologies, underpinned by contemporary pedagogical theory. In practical terms it has provided a worked example of how the affordances of learning technology can, within this pedagogical context, be mapped onto a very real and often problematic teaching and learning scenario that faces educators in archaeology today – that of the provision of field based learning and teaching (Holtorff 2004).

As part of this example, it has demonstrated an alternative technological platform for delivering interactive 3D models to the ageing and developmentally moribund VRML format. In doing so, it has provided an interactive reconstruction of Arbor Low that enables an embodied first person experience of how the architectural features of bank, ditch and up-righted stones form a gradation of space within the monument. This would not be possible to experience by visiting the monument itself in the present day. As a result of this, it has provided further evidence to suggest that 3D models do not need to conform to ideals of photo-realism to be valuable, and instead that their value depends on their intended use and fitness for purpose.

The examples also demonstrates how the products of three related technologies (GIS-based viewshed maps, PVR representations, and 3D models) can be integrated using a fourth, that of interactive multimedia, and that this can be delivered in the context of a fifth, that of e-Learning facilitated by Learning Technologies. Although these products need to be originated independently, they can be integrated at the point of delivery. In doing this, the example has captured an unexpected synergy between the PVR representation of the monument and its viewshed map, by using the PanoraMap approach. The example also shows how the manufactured deficiency present in the 3D model can be ameliorated by the context of its use, in two ways. Firstly, it can be combined with the photo-realistic PVR representation of the monument as it can be experienced today, with integrated navigation. Secondly it could be used at the monument itself, in situ, on a mobile device as a form of Augmented Reality.

8.2.7 – Comparisons with other studies

There appear to be relatively few publications regarding the use of learning technologies and archaeology within an HE context. Having said that, a number have appeared in the last five years or so that place the use of learning technology within a contemporary pedagogical framework (Kilbride et al 2002, Nixon and Price 2004, McElearney 2004, Mowat 2002, Wace and Condron 2002). It is hoped that this study may serve as a potential model for the use of interactive multimedia in teaching archaeology.

The integrated use of PVR and 3D representations as presented here also appears to be relatively novel within archaeology, with the notable exception of the work of Exon et al (2000). The 3D model itself shares the same philosophy and epistemological background as those created for Avebury (Pollard and Gillings 1998), Danebury (Earl 1999) and Thornborough (Goodrick and Harding 2000). Each of these studies eschew the pursuit of photo-realism and instead focus their attentions on providing alternative representations that can be heuristically explored for research purposes.

8.2.8 – Limitations and Future Research

This part of the study again can be enhanced technically, pedagogically and theoretically.

Some of the examples in the case study are arguably a little trivial. This is because they were included to demonstrate the affordances of the technology, rather than serve as a "live" example. These could be developed much further were they to be used in an actual course environment. The whole package would require further development to make it conform to current accessibility regulations. This would be a significant but resolvable challenge, particularly in those parts of the package that are reliant on use of the mouse. For example, the selection and manipulation of the stones in the 3D model would need to be made using the keyboard, possibly by "tabbing" through them to select, and adjusting their positions using the arrow keys. Text equivalents for the voice over in the Exploring Prehistoric Landscapes clip would also be needed for those with hearing impairments.

The 3D models themselves could be enhanced beyond their current rudimentary state. They are currently a little de-contextualised because there is no sense of horizon, and no landscape setting – so for example the fact that the henge sits just off a natural ridge is not presented. By taking a further series of panoramas from outside the henge, it would be possible to at least include the modern horizon as a background. Placing the monument on a representation of its immediate landscape setting would enable more of a sense of encounter, rather than just immediately arriving there. If the ability to view landscape in a detached and disembodied way from a map perspective can be called a "god trick" (Haraway 1988), then this sort of sudden arrival at a place with no sense of travel, encounter or expectation could be called a "teleport trick". Both are most un-natural. Finally, whilst providing and embodied experience of the monument, it is also a somewhat solitary one.

The model could theoretically be populated with some intelligent automotive agents, which could be programmed to behave in certain ways, perhaps choreographed into some form of ritual procession.

In pedagogical terms the effectiveness of the package has not been evaluated with students, and this would also be an immediate priority were it to be developed further. Evaluation is crucial in e-Learning, as it provides the primary means of data collection for educational research, and most recent research papers in the field are based around evaluative studies. It is becoming an increasingly established field, and again one not without its own raft of theoretical and practical considerations (Conole and Oliver 2003, Oliver 2000).

The evaluation of virtual reality in education presents specific issues of its own, particularly regarding more subjective experiential aspects (see 7.4). Some evaluation work on the use of desktop virtual reality in learning has recently been undertaken in Sheffield. In 2004, an interactive 3D modelling environment was produced for students of Landscape Architecture (Clayden et al 2005). Deliberately hyperreal in its use of simple forms and colours, the package was designed to aid students of this discipline in their learning about the structuring of space. Results of detailed evaluation, using focus groups and interviews with both staff and students, suggested that using the package had enhanced their appreciation of space (ibid). These findings are still difficult to interpret – if a student feels that their understanding of the articulation of space has been increased, then there is perhaps little else that can be said on the matter, short of trying to metrically assess whether the quality of their work has improved. The results of more longitudinal evaluation from these students is keenly anticipated.

Returning to the issue of the solitary experience of Arbor Low described above, this could also be potentially resolved by placing the 3D model within a multi-user environment. This could theoretically enable students to interact with other students and/or lecturers, as represented by *avatars*. Students could interact with each other in a journey of discovery, or could be more prescriptively guided, possibly with an actual guided tour by a lecturer. It should of course be noted that for traditional campus based students, it might be more cost effective and pedagogically satisfactory to hire a coach at this point.

A final potential development considered here that spans both technical and pedagogical issues would be to locate the model within a gaming engine (Anderson 2004, Champion 2003). These highly optimised software packages offer liberation from any of the performance issues encountered with VRML or Shockwave. Several games now include level editors, in which one's own environment can be created, or imported from another modelling package, e.g. Quake (Anderson 2004). As well as the performance issues, these would enable multi-user functionality, and activities could be introduced in the form of retrieving clues etc. This area is starting to receive much interest within the field of e-Learning and Learning Technologies (e.g. Gee 2005)

There are broader concerns with the whole e-Learning agenda, and these have already been discussed in section 7.6.4. The resolution of these is beyond the scope of this study.

8.3 – Integration and synergy – tying it all together.

The above discussions have shown mainly how as individual technologies, the GIS analysis, PVR representations and 3D models have their roles in addressing different aspects of spatial scale. It is argued that even prior to any integration, they have generated new knowledge and provided new insights in their own rights. In this section, areas of integration and synergy are discussed.

Firstly, it should be established that all the technologies can be used together to provide a composite picture. They were not necessarily designed to be used together, but they can at least be conceptually integrated in the mind of the archaeologist. They do however, prior to the integration suggested below, still exist as separate entities in their own rights. They are not integrated by default, and to achieve this requires some intervention.

The first area of synergy to be considered is that between the GIS viewshed images and the PVR representations. As highlighted in Chapter 3 (3.4.2.3), by default GIS derived viewshed images are displayed using the metaphor of the map. Problems inherent in this format have been referred to throughout this study, and in the specific case of viewshed analysis, they simply serve to provide a detached view of what is supposed to be an embodied subjective experience. It is argued here that this first area of synergy, in which panoramas are dynamically linked to viewshed maps to create *embodied viewsheds* goes at least some way towards resolving this issue. In doing so, it can reveal other insights that would not be demonstrated from the viewshed alone. An example of this has been demonstrated at Tideslow, where the architectural form of the monument makes it impossible to see the full viewshed from any one point, and thus invites movement around the monument in a way that may not have been dissimilar to ritual processional activities in the past. There are of course limitations to the technique, and these have largely been discussed above and in Chapter 5.

As well as just illuminating these viewshed maps, the combination of both can also be used to document ground-truthing exercises in the field. The importance of this should not be underestimated, because of the many potential sources of error involved in conducting viewshed analysis. This is especially the case when combining the results from many monuments in CVA based studies, where individual errors can easily be propagated (Wheatley 1995). Not only can these representations be used as "proof" of a phenomenon, but they can also provide a dynamic spatial narrative that invites movement through the phenomenon. If Chris Tilley had been given access to this technology in 1994, then *A Phenomenology of Landscape* may have been a very different kind of work.

The single most unexpected synergy between these two technologies is without doubt that encountered in the example at Arbor Low. Following the general arguments proposed for the architecture of henges, and more specifically ideas suggested by Bradley (1998), the original motivation behind this example was simply to demonstrate how the banks of the henge would constrain one's vision of the landscape beyond. The actual results then were totally unexpected. Over and above the ontological benefits from this juxtaposition, this also provides a presentation of this general principle in a way in a way not available by conventional means (ibid: 125 Fig 40).

A second area of synergy can be seen in the combination of the PVR model of Arbor Low, with its 3D modelled counterpart. This combination goes some way towards countering the problems of the *manufactured deficiency* of the model (Gillings 2002). By having immediate recourse to a photo-realistic representation of the same place, it is argued that the student/user would not have to interrogate the 3D model with the kind of suspicion described by Dovey (1985). Instead their cognitive faculties could remain focussed on experiencing the 3D model for what it is – a reality faithful only to itself (Gillings 2002). A second synergy, in educational terms, is that it could help students to understand the potential relationship between how the monument appears today, and how it may have appeared in prehistory. Deploying this combination on a mobile device at the monument itself would only reinforce these synergies.

A third area of synergy is to be found within the integrative capabilities of interactive multimedia. As well as being able to package the results from the GIS analysis, the PVR representations and the 3D models, the multimedia environment adds synergies of its own. These include the ability draw on other forms of digital media, e.g. video, provide a narrative structure, and provide other forms of relevant educational interactivity that is not capable in either one technology alone. Importantly, this combination, when delivered via a Virtual Learning Environment, can be integrated within what are considered to be the more "social" forms of learning technology – discussions boards, web logs (blogs) etc.

Over and above the integration between these technologies, and synergies found in their combination, there is a final broad area of integration – that of purpose of use. This means that in that in the current climate of teaching and learning within Higher Education, and in a research led university using e-Learning within the context of constructivism and Inquiry Based Learning, the same procedures and outputs that are used for research can also be used to facilitate learning. The sense of discovery encountering and redefining the architectural configuration at Arbor Low can be shared and enjoyed by the students as well as the academic researcher. The study has shown that the boundaries between what might be considered as *research* software applications, and *presentation* applications, do in fact break down. Research tools can be used in the presentation of knowledge, or more importantly the construction of it. That you would almost expect. Perhaps more surprisingly is that technologies one might associate with presentation reveal themselves to have a very direct role in research, so the traffic runs in both directions – research informing presentation and presentation informing research.

One key area of technology integration originally planned that has failed in this study has been the integration of broad regional landscape visualisation with more close-grained architectural reconstructions. In particular it was hoped that it would be possible to devise a means of navigating large areas of realistic looking terrain quickly, and then be able to zoom in to the scale of a monument in a seamless environment. This has remained elusive up to this point, but is starting to become possible. This has not been realised by the conversion of GIS landscapes into VRML models as was initially envisaged, but is now possible by remaining within the GIS environment, as packages like ArcView now allow the importing of 3D models into their ArcScene module, which also enables interactive fly-through type navigation over large terrains. A second, and totally unexpected way of achieving this is becoming possible using Google Earth, and this is discussed further below.

Finally, despite all the theoretical rhetoric about the need for multi-sensory experiences, all the techniques and discussions above have centred around a series of representations that once again reify the primacy of vision. Although our conceptions of landscape and a "primacy of vision" may be modern historical constructs, and although there is a wealth of ethnographic evidence to indicate the importance of non-visual sensory engagement with the landscape, it may also be true that "the visual appearance of a place is, in most cultures and for most people, the most significant impact a location has upon any individual's many senses" (Wheatley and Gillings 2002: 201). This is certainly where the affordances of the technology currently offer most.

8.4 - General Discussion, and Broader Implications for Future Practice.

An unexpected result of this study is that all three of the technologies considered have elements of their epistemological trajectory in common. These are that they have been through periods of early adoption, that this has at times been uncritical. There has since been recognition of these problems, and authors have worked hard to establish a valid theoretical framework for them and laid down some key principles. Now (where we are right now in all three), and only now, are we in a post-critical phase of adoption. This is true of the use of GIS in archaeology, Virtual Reality in archaeology, and of e-Learning and Learning Technologies across all subjects. Ironically, although Learning Technologies are the oldest of the three areas, it is also in this field that the paradigm shifts have been most recent, and this has been the move away from instructivist approaches towards *teaching*, towards constructivist models of *learning*. This is where the work can really start. Because we have the theoretical underpinnings established, we have the tools to critique and evaluate, as well as move forward in our practice. Or rather having more accessible means to practice – viewsheds are easy to create, 3D models are getting easier, and basic web page creation is easier than word processing (this is because the options are much more limited).

The uncritical use of viewshed analysis has partly arisen because of the ease with which this operation can be performed in modern GIS software. But is the "push button functionality" of GIS such a bad thing? (Wheatley and

Gillings 2004:2). The user friendliness of modern systems provides a form of accessibility to the technology that gets more people thinking about it, as called for by Wheatley (2004). If it were still necessary to write Arc Macro Language scripts to do basic forms of viewshed analysis, would many contemporary theoretical authors engage with it at all? GIS research would remain the province of the specialist, and thus only exacerbate the technical-theoretical dichotomy that such authors have argued against in the past. Without critiques generated by key authors, GIS would have remained in the theoretical naivety that characterised so much of the work published during the early 1990s.

In terms of the approaches presented in this study, the construction of 3D models in 3D Studio Max, and the integration of the various multimedia components most certainly is *not* push button functionality. Not only are there factors of cost and effort to consider here, but issues of theoretical engagement. It has been demonstrated that for authors to effectively use either GIS and/or VR in archaeology, they need to have a grounding in the theories that underpin either or both technologies, as well as a firm foundation in archaeological on which to base their use. For those wishing to integrate the use of these within an e-Learning environment, there is a need to engage fully with the theoretical and pedagogical issues surrounding this discipline as well.

Towards the closing months of this study, Google released Google Earth, a freely downloadable package that allows landscape visualisation and navigation at a global scale. In parallel with this, a "new player" has come to light in the world of 3D architectural modelling software – SketchUp. SketchUp allows the rapid and simple creation of 3D models. Making no attempt to achieve photo-realism, SketchUp allows the creation of models without the costly and challenging learning curve that confronts users of 3D Studio Max. Most importantly for this study, these two technologies have a synergy that now renders the previously unattainable goal of wide area landscape visualisation combined with close-grained archaeological reconstruction as a very real possibility. This is because SketchUp models can be saved in a format that allows them to be included as "markers" within Google Earth. This means that 3D models of sites can now be easily created and be visualised within their broader landscape context. SketchUp is available for use within HE Institutions at a massively discounted cost, and the University of Sheffield has a licence to allow 60 concurrent users. This means that the creation of virtual models for archaeological research and teaching could now be performed by the students. That Google Earth is free, and does not require an expensive and complex GIS environment means that there has been a democratisation of visualisation technologies hitherto unseen. An exploratory "proof of concept" of this is shown in Figure 8.1, wherein the model of Arbor Low has been placed in its landscape context.

This final point is worth developing a little further, as it has implications that reflect broader changes in pedagogical paradigms, and it is in this area where things have changed the most in the last 10 years. If this study had been produced as little as five years ago, it probably would have presented these technologies from an instructivist perspective. The reconstruction of Arbor Low would have been presented as is, in its finished state. As the constructivist paradigms of learning have become more embedded, so has the perspective of the author of this study, so now the model of Arbor Low has been presented as a world in which students can create their own reconstruction, and in doing so construct their own subjective experience and knowledge. This basic philosophy can be extended out to encompass the other materials presented here. Rather than simply give students GIS images to look at, the whole analysis presented in Chapter 4 could have been produced by the students themselves, as a collaborative activity. Students could create viewsheds for a few monuments individually, and share these via a VLE. This is where the implications of SketchUp become apparent – students could be taught its basic use, and could then go off and create their own archaeological reconstructions, and these could be shared using Google Earth. Students could collaboratively create their own Google Peaks, Google Lakes, Google Wessex, or wherever. Rather than just acting as passive recipients of *content* produced by an expert content provider, students can become responsible for creating content for their own and their colleagues learning. The idea of students creating this kind of material is not in itself new, and the creation of VR environments by students was reported by Youngblut in her survey during the late 1990s (1998). Neither should it be considered simply as a means of producing content "on the cheap". Evaluation of the Digital Landscape Space package here in Sheffield has demonstrated that students' subjective understanding of space can be increased by actively engaging in creating virtual representations (Clayden et al 2005). Even more recently, Earl has noted how the process of creating a model gives provides a very intimate encounter with the monument being reconstructed, and that "in order to fully understand the modelling processor one should be able to model" (Earl 2006: 202).

This study concludes on a positive note, by reiterating the point about the epistemological trajectories of the technologies presented here. In all three areas we have now entered a phase of post-criticality. Wheatley et al have recently stated that "archaeological computing will benefit less from new technologies per se and more from the convergence of existing technologies" (2002: 3). This would seem to suggest that we should be pursuing areas of synergy between these technologies, as has been attempted in this study. Gary Lock has recently expressed disappointment that the available technologies do not yet allow the sort of subtle appreciation of landscape described in Keith Basso's "Wisdom Sits in Places" (Basso 1996, Lock 2000). Although this may be true, it is not clear from the literature that anybody ever expected that they would. Whilst all three technologies still have theoretical and methodological issues to resolve, these have now been identified, and work can usefully progress now that these have been made explicit.