1

Introduction

> **Astro-archaeology**, encompass[es] the study of astronomical principles employed in ancient works of architecture and the elaboration of a methodology for the retrieval and quantitative analysis of astronomical alignment data. The alternative term, **archaeo-astronomy**, came to embody, the study of the extent and practice of astronomy among ancient cultures. – Anthony Aveni (Aveni, 2001: 2).

This research initially focuses on the methodology of the former definition within the quotation above, that of astroarchaeology, sometimes referred to as statistically based, or green astroarchaeology (Aveni 2008; 8). The main impetus is to visualise accurate 3-dimensional virtual reality representations of 12 megalithic sites of Argyll, Scotland, within their topography by developing and utilizing software tools to test for any celestial orientation for each site. Subsequent to the astroarchaeological interrogation of the sites, the focus shifts to the alternative term in the quotation above, that of archaeastronomy, referred to as 'brown' or archaeoastronomy (Aveni 2008: 8), by leveraging the visually demonstrative images within a wider cultural context, to aid in the furthering of archaeological hypotheses. Followed by a discussion of cultural context as it relates to the builders of the site; thereby providing a posteriori data to assist archaeologists in expanding the accumulative, archaeological record.

This is an innovative, novel approach, employing multiple software tools, a style that falls within the realm of experimental astroarchaeology, therefore, initial results can only be considered preliminary, requiring further expansion into other sites and refinement of measurements, to verify or refute any determinations made. Any positive astronomical findings, however accurate, without written record to support them, can only be considered conjecture as to the Neolithic peoples' intentions for these megalithic sites. Using modern day tools and technology must never separate us from the archaic time in question. The perspective of the era under review must be maintained, as if the computerized images created, enable us to be the eyes of the herdsman who sat night after night, with one eye scanning for predators, and the other observing the heavens above.

Our contemporary understanding of the cosmos explains how an event may be interpreted, but as investigators and researchers, we must attempt to suspend theoretical disciplines such as geometry or celestial mechanics and instead, attempt to envisage the Neolithic peoples' perspective in recording celestial observations in stone. If not, the derived results would have to be treated with circumspection. The contemporaneous perception of a singular point upon the horizon may well be considered, but any investigation must not be restricted to only this point of view. Therefore, the phenomena of the rising or setting of a celestial object or the association of multiple celestial events should not be excluded or indeed, anticipated.

1.1. Astronomical Archaeology of British Monuments

In the early 20th century the astronomer Norman Lockyer, discussed the potential of the alignment of celestial bodies to ancient stone monuments, with his paper *Stonehenge and Other British Stone Monuments Astronomically Considered* (Lockyer, 1906b). Lockyer introduces his hypotheses regarding the rising and setting of stars as date indicators, and on the possible solar alignment at Stonehenge. In addition, he initiated modern day investigative methods by providing surveying techniques that consider celestial orientations, in his *Surveying for Archaeologists* (1909). Alexander Thom (1955) an Oxford professor of engineering conducted extensive site surveys throughout Britain and Europe, employing such techniques.

Alexander Thom's studies did not permeate to the general-public, until Gerald Hawkins of the astronomy department of Boston University, introduced the topic to the public with his publication *Stonehenge Decoded* (1965) and subsequent television programme. The work of each of these individuals dealt with the mechanics of the alignments, with very little consideration for the anthropological aspects, and fell within the definition of astroarchaeology. Lacking the cultural context, it failed to enter the mainstream of the archaeological world. In fact this statistical approach to setting both the date of construction for the structure and stipulating the purpose of the megaliths as astronomical sites, without supporting archaeological evidence, rankled the established archaeological community. The disciplines of astronomy and archaeology continued to remain separate until advances in techniques and technologies, from sciences outside these fields, enabled archaeologists to delve more deeply into the analysis of archaeological sites, and interdisciplinary site investigations began. A synopsis of the divergent viewpoints that arose is best portrayed in the introductory chapter of *Astronomy in Prehistoric Britain and Ireland* compiled by Clive Ruggles (1999: 1-11).

The works of Thom and Hawkins were the foundation of a new discipline in evaluating ancient sites that ranged from European megaliths to American Indian mounds. An almost encyclopaedic and concise historic record of

investigations into the astronomy of sites worldwide is provided by Kelley and Millone (2011). Within the Americas, investigations continue into the astronomical significance of archaeological sites, aided by the availability of ethnographic and historic records (Aveni: 2008).

Ruggles' (1999) publication provided a comprehensive analysis of astronomically linked sites throughout Britain but similar contemporaneous investigations have diminished appreciably. There continues to be reluctance on behalf of archaeologists to accept astroarchaeological research, unless it is accompanied by some cultural assessment; that being said, the dates derived for the sites by Thom's methods permeated into the body of archaeological text. Thom's generalised dating of Neolithic sites in Britain (1978: 44) to around 1750 BCE, is utilised in several publications, targeted to the anthropological and cultural perspective of those sites. The publication of John Wood utilising this dating schema (1980: 84-85), is such an example.

British megalithic sites have been investigated by interested parties since the first attempt to analyse Stonehenge in the 17th century. An interesting aspect of the Scottish sites is, the larger the quantity of stones, the greater the enquiry they generated over the centuries. There are a multitude of surveys and plans starting in the 18th century, for sites such as the Ring of Brodgar (Averil, 1974), and Callanish (Callender, 1856*)*. Whereas, the majority of sites that contain the lesser quantity of megaliths have received significantly less documented attention. Campbell and Sandeman (1964) undertook to record all possible archaeological sites within Argyll Scotland. Their effort resulted in a document used, to this day as a reference, by the Royal Commission on the Ancient and Historic Monuments of Scotland (RCAHMS). However, the extensive work that became the foundation of in-depth research as to any astronomical aspects to these megalithic sites was that of Alexander Thom (1967, 1978).

1.2. Thom's Research Methodology

Thom's first papers in the middle of the 20th century (1955, 1961), were primarily targeted toward local archaeological groups and professional audiences, but, as stated previously, came to the attention of the general public after Gerald Hawkins publication (1965), and subsequent television programme, *Stonehenge Decoded*. At this time, Thom applied his engineer's perspective to site design and astronomical 'alignment', publishing his interpretation in *Megalithic sites in Britain* (1967) and *Megalithic Lunar Observatories* (1978), offering the public a perception of scientific accuracy.

Thom's extensive surveying of megalithic sites, engendered interest in the less prominent and smaller arrangements. When assigning an orientation to a stone, Thom stated that, 'the most difficult part of the whole investigation is to decide which horizon point to include and where to exclude. The decision must always be a matter of personal opinion and is influenced by the viewpoint and the other lines with which, at all times, it is being compared' (Thom: 1979, 96). By this very statement the 'horizon point' was subjective, and to argue, for or against any orientation, researchers, such as Ruggles, et al (1984), followed the same investigative path, to either support or refute any arguments. Thom also employed his subjective method of selection of an horizon point, via personal choice, and calculated high precision alignments with the megaliths at sites outside of Britain; for example, the prehistoric site of Carnac (1972). However, Thom's conjectures of mathematical precision in construction and alignment, generated reservations, dissension and circumspection initiating further interrogation to verify or refute his claims. Investigations into Thom's assertions followed his publications, creating academic argument both for (MacKie: 1977a) and against (Ruggles: 1999, Patrick: 1979). In fact, the die was literally cast, as Thom's approach of assessing astronomical orientation along the sides of stones in conjunction with his date of ~1750 BCE became the driving criteria that future researchers employed.

Aveni (1988: 442) describes Thom's method of collecting copious field measurements, from which '…first find the solstices, then, if successful, look for the lunar limits' as the 'Thom Paradigm'. Aveni felt that Thom's premise and high precision conjecture, lacked archaeological records to substantiate or refute his findings. His major concern was how Thom's paradigm had been employed in the Americas where archaeological, verbal and written records do exist in determining whether celestial events would have been part of the culture. This is a reasonable concern on Aveni's part. Unfortunately, verbal and written records for prehistoric times in Britain, which reflect cultural aspects of life, do not exist; even archaeological records in association with the sites are limited. This very lack of written or verbal record is a primary driving force behind determining whether or not, astronomy was a part of the cultural life of prehistoric Britain, and whether that astronomical involvement, is *recorded in stone* as suggested by the title of the book in which Aveni's paper appears.

A variation upon Thom's approach was undertaken by Gerald Hawkins (1965) in his computerized analysis of Stonehenge, whereby he used the positional data of the stones to determine orientation between the stones and either a solar or a lunar event. When such computed alignment occurred, it was thus concluded that this stone or site must have astronomical intent. To borrow from Aveni, I refer to this approach as the 'Hawkins paradigm'.

Since Thom's dating assessment of these sites, the advent of plate tectonic investigations, and an improved quantification in the land uplift due to isostatic movement, may modify or negate his dating. This research will determine the amount of land motion incurred by these sciences, as described in online chapter A1, and investigate

the implication, if any, of both tectonic and isostatic movement as each site is modelled, and examined through simulation.

1.3. Visualising the Past

Several undertakings using computers to re-create buildings and archaeological sites have been conducted to aid in visualising how the sites may have appeared in their original guise. Following are three examples: roman villas have been re-created, and an impressive representation of Egyptian tombs in the Valley of the Kings have also been generated in 3-D, under the guidance of Dr. Kent Weeks of the Department of Egyptology at American University in Cairo (Theban Mapping Project 2008, accessed 21st January 2009**,** <http://www.thebanmappingproject.com/>). Under the direction of John E. Hancock, professor of Architectural History at University of Cincinnati, a reconstruction of the Ohio Valley, as it may have appeared centuries ago, was produced. (CERHAS, the Center for the Electronic Reconstruction of Historical and Archaeological Sites, in the College of Design, Architecture, Art and Planning at the University of Cincinnati 2007, July 2008) <http://Earthworks.uc.edu/products.htm> Thirdly, Houdin, & Brier (2009) modelled the Great Pyramid at Giza to test the hypothesis of an internal ramp as a means of construction.

The purported, astronomical alignment of megalithic stone rows, judged by viewing the supposed alignment along the flat surface of a stone, is necessarily restricted to the observation by a single observer looking directly at the astronomical sphere as it rises above, or sinks below the horizon. This is indeed a viable means of observing as far as the planets, stars and Moon are concerned, but more difficult with the Sun due to its brightness. Whereas, using the shadow and bright light lines cast by the Sun is a practical way of 'drawing' straight lines in nature. For a specific orientation, all any observer needs to know, is the day upon which the delineating bright light-shadow line may be observed, thereby, avoiding looking directly into the glaring Sun. At enclosure type-sites, such as Newgrange, and Dowth in Ireland (O'Kelly 1983, Eogan 1986, Brennan, 1994), at the time of the winter solstice, the Sun may be observed indirectly as its light falls within a chamber.

Another aspect to consider at the rising or setting of an object, is what portion of the sphere is observed above the horizon; the upper limb, the centre, or the lower limb, which may indicate whether the sites were constructed to a solar or lunar event.

To summarise, some identifiable benefits of this computerised approach are:

- It allows for the testing of theories, when local conditions may make on-site testing impossible.
- A singular observation point implies a singular observer. Whereas, phenomena that may be viewed by multiple observers implies a broader viewing perspective, the research may disclose such instances. Interestingly enough, a single 'observer' could also act as a gnomon, the shadow caused by the individual – becomes the event to be observed by everyone else.
- Locations from which to observe celestial orientations as they relate to the megaliths are not marked or identified, or no longer exist; therefore, opportunities are made available to test for viewing points re-created in 'pristine' epoch conditions, which only simulation can provide.
- Many sites' purported alignments are with distant horizons or mountain slopes, which on a flat piece of paper seem feasible. The use of Global Information Systems (GIS) will incorporate the 3-dimensional aspects of the surrounding countryside resulting in a more deterministic and realistic evaluation.

A driving impetus of this research was to examine whether one or more of the aforementioned factors might be demonstrated, as well as the development of an approach in experimental astroarchaeology that may be repeated and therefore tested by other researchers. The reconstruction of the vista of the Neolithic sky may move us closer to gaining an insight into how people in the distant past regarded themselves within their natural surroundings. Consideration was given to provide statistical analysis, similar to previous researchers; however, such statistical analysis was limited, due to the following reasons:

- Researchers such as Thom (1979: 102) and Ruggles, et al (1984, 1999) employed histograms of horizon bearings in association with stones across the sites they investigated. They included possibilities of those bearings having significant mathematical high precision, accurate orientations, to a pre-selected and therefore, subjective, horizon point, where a celestial event may occur. The research approach within the present book however, conducts the reverse methodology by examining mathematical high-precision celestial events in association with the landscape and a site's horizon, then through modelling, posits questions such as, are there any indications that a stone has any potential orientation? A clearer, demonstrative 'yes' or 'no', results thereby, minimizing the need to resort to statistical interpretation.
- The limited number of 12 sites modelled in this research – does not permit a broad enough sample for statistical testing.

1.4. Software Considerations

This section serves as a summary introduction to the software selected; additional in-depth details are given in chapters 3 and 6.

As the main impetus of this research was to visualise an accurate 3-dimensional representation of the sites and the topography in which they are located. The acquisition and display of topographic data and the re-creation of the megaliths set the selection and procedure of execution,

for the required software. A search for software to meet these requirements was undertaken. Certain limitations within existing software packages, forced the re-creation of already accurate and well-respected celestial display systems. For example, star projecting software such as Skymap© and Solarium© may permit the inclusion of a user's selected horizon line but they are unable to incorporate or interface with, a 3-dimensional landscape. This restriction forced the same star projection function to be independently programmed by me. Fortunately, these already well functioning packages could be used as a verification of accuracy in the independent programme. However, the selection of the appropriate software language, that the programming had to be created in, was restricted by the need to marry all aspects together.

Tools to model the stones were also evaluated from the industry de facto computer aided design (CAD) standard Autocad® to that of tools specifically targeted to generating computer games. Again, limitations reduced the selection to a fast and accurate 3D modelling tool – AC3D™ – developed by Andy Colebourne from the computing department of Lancaster University.

Accurate rendering of the visual models created, was a major concern. One tool with this requirement was PovRay (Persistence of vision Raytracer), which came with other advantages: i) a programming language in which the celestial computations could be written and incorporated, ii) the ability to import the AC3D created models and iii) the ability to incorporate the 3-D topographical maps. Other software tools to refine the process are discussed further in chapter 3.

The foregoing topics are addressed in the following manner. Underlying background information of previous works, and the approach they influenced, is presented in Chapters 2 (Previous Research) and 3 (Approach). As the approach to the investigation is to consider a range of time across several millennia, the aspects of celestial mechanics, environmental conditions, and the location of the monuments through land movement, over that date range, are presented in chapters 4 (Computing the Neolithic Sky), chapter 5 (Changing Environmental Landscape) and the online chapter A1 (Changing Geographic Landscape) respectively. How the models are created and combined with the data from chapters 4, 5, and A1 is described in chapter 6 (Model Construction).

In preparation for conducting the interrogations via computer simulations, issues relating to modelling the topology, are addressed in chapter 7, before describing the placement of the models in the topographical landscape. With the models constructed for each site the experimental research was then undertaken. Chapter 8 (Investigative Models), describes the detailed interrogation into each of the sites selected, with an expansion on background research data where applicable, and the resultant objective empirical data, derived from such interrogations.

Chapter 9 (Society and the Stones), discusses models of the society that constructed the megaliths for the purpose of setting a framework for the analysis of the results from the models presented in chapter 10. Chapter 10 provides an interpretation of the results by combining the empirical data derived from the investigations and analysis of chapters 7 and 8 respectively, with societal aspects presented in chapter 9. The multitude of time related simulations, accompanied with a summary of findings, allows for all site survey data to be collected together, enabling site comparisons, and subjective interpretations ascribed. Conclusions are then drawn in chapter 11.